# In Starland with a Three-Inch Telescope

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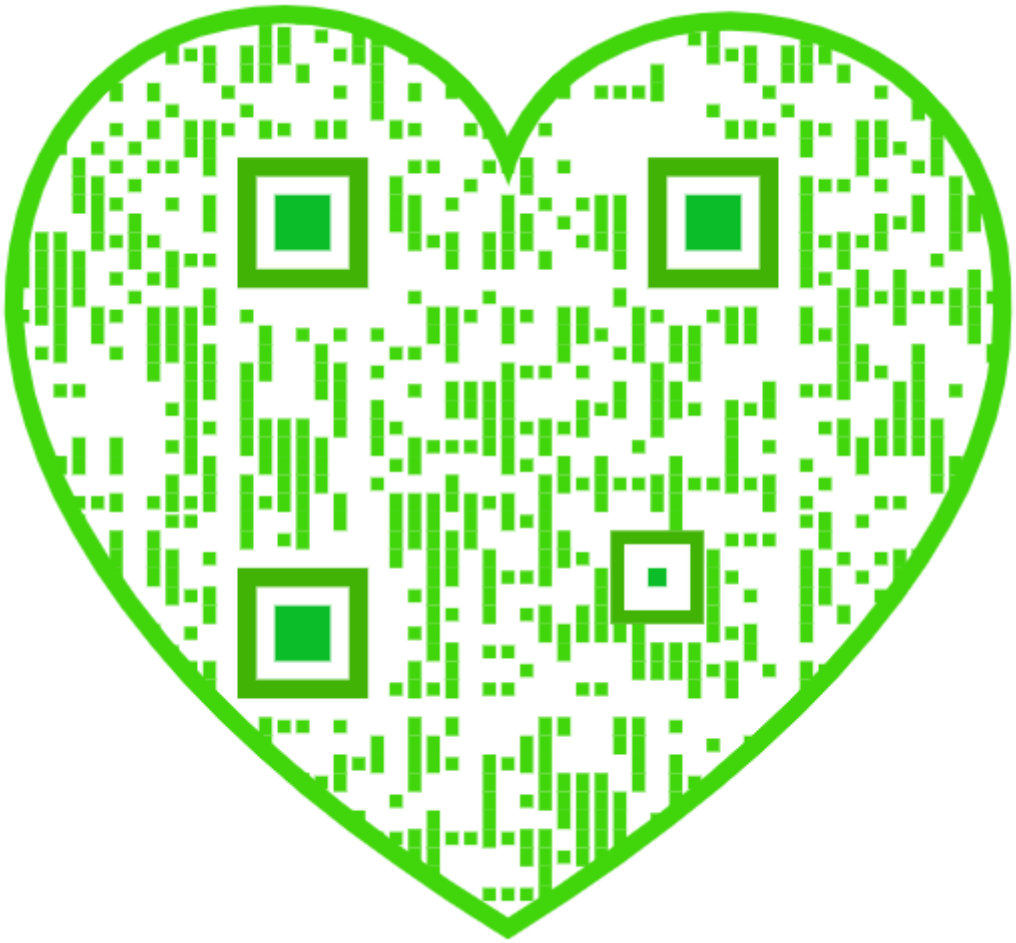
William Tyler Olcott



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By William Tyler Olcott

A Field Book of the Stars

In Starland with a Three-Inch Telescope

# In Starland
# With a Three-Inch Telescope

A Conveniently Arranged Guide for the Use of the Amateur Astronomer

With Forty Diagrams of the Constellations and Eight of the Moon

By

**William Tyler Olcott**

Author of "A Field Book of the Stars"

G. P. Putnam's Sons
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# INTRODUCTION

THE sole purpose of this book is to afford a convenient guide for the amateur astronomer when engaged in telescopic observation.

Aside from a study of the moon's surface, the observation of double stars is sure to prove the most attractive work for the possessor of a small telescope. The brighter doubles the novice will have no difficulty in finding, but those below the third magnitude are often difficult to locate without reference to a diagram of the constellation of which it is a part—hence the author has seen fit to place such a diagram where it can be easily consulted.

It is presupposed that the owner of the telescope is familiar with the constellations. It then should be an easy matter, with the assistance of the accompanying diagrams, to find the double stars mentioned in the text.

The constellations are grouped under the seasons for the sake of convenience.

Many of the stars have faint companions of the ninth, tenth, or fainter magnitudes. These doubles are interesting solely to those who desire to test their eyesight, or the powers of their glass. They are disappointing as compared with the beautiful doubles the magnitude of whose components are more nearly on a par, such as



211774

Castor, (γ) Leonis, (γ) Virginis. The author has therefore arranged the doubles to be noted, so that those most worthy of observation come first in the column assigned to them.

The chapter on the moon is arranged according to the same idea as the matter on the double stars, conciseness and brevity being especially aimed at. The pleasures of selenography are so fascinating, that the author feels assured that the student will add to the brief outline here given by collateral reading. Only the principal objects of interest are mentioned in the text accompanying each successive view of the moon. The observer will note a wealth of detail in every peep he takes at the moon that will add greatly to his pleasure.

In a word, then, the *raison d'être* of the book is convenience of arrangement. The author has found by experience that what the student most needs when he is observing with the telescope, is a page to glance at that will serve as a guide to the object he desires to view, and which affords concise data relative to that object. The diagrams therefore direct the student's vision, and the subject matter affords the necessary information in each case.

The fact that there are so few telescopes in use, comparatively speaking, in a great measure accounts for the little interest in astronomy taken by the public. If these pages serve to awaken the slightest interest in the fascinating study of the heavens, the author will feel amply repaid.

## THE DIAGRAMS OF THE CONSTELLATIONS

THE diagrams represent the appearance of the constellations in the season in which they are placed, and favorable location for observation was chiefly considered in thus grouping them. The student can vary the arrangement to suit his convenience.

As the winter is the least desirable time for star-gazing, the greater number of constellations have been purposely grouped in the other seasons.

The so-called "circumpolar constellations" are of course available for observation at any time of the year, and the student can choose his own time for studying them.

At the foot of each diagram of a constellation, for ready reference, appears the name and page number of the constellations bounding it.

Only the constellations visible in the latitude of the New England and Middle States have been included in this book.

The author presupposes that the telescope to be used in connection with this book is not equipped with circles, otherwise recourse should be had to some such book as Webb's *Celestial Objects for Common Telescopes*, for a more

exact location of the objects of interest, in terms of Right Ascension and Declination.

For the most part only double stars with a primary of the sixth magnitude or brighter are given, as it is difficult to direct the telescope at a star of lesser magnitude unless its position is accurately known.

In searching for double stars many faint yet beautiful pairs and triples are observed, so that it is well to have such a book as Webb's, in order that these objects can be identified.

The diagrams include over three hundred double stars, and the sight of these and the many fine clusters and nebulæ mentioned should afford the happy possessor of a telescope many hours of keen enjoyment.

Considerable discrepancy will be noted in the colors assigned to the double stars, and those observed. The coloring in many cases is at best elusive, and atmospheric conditions and peculiarities of vision play an important part in determining it. In a number of cases the colors are very pronounced and render the object of surpassing beauty, as for instance in the great favorite ($\beta$) Cygni. The first color given is that of the primary or brightest star, the second color given is that of the companion.

The position angle measures the inclination to the meridian of a line drawn through the double stars. It shows the observer where to look for the companion star, and is reckoned from 0 degrees to 360 degrees, beginning

at the north point, and proceeding through the east, south, and west to the north. The student should bear in mind in this connection that in the telescope the north and south points are reversed.

The decimals are omitted from the distances given between the doubles (which are from centre to centre, and in seconds of arc) as in the wider doubles, as most of those referred to in the text would be termed, absolute accuracy in measurements, for purposes of observation purely, is non-essential.

A three-inch glass should split stars that are distant from each other 2.3″. Of course this question of splitting doubles depends in a great measure on the power of the eyepiece used, the condition of the atmosphere, and the quality of the eyesight of the observer. Serviss recommends a power of from fifty to seventy to the inch of aperture. The author has succeeded in seeing the great majority of the doubles mentioned in the text with a power of 130.

The term "light year" which is used in the text is the usual term for expressing the distance from the earth to the stars. A light year is the unit of such measurements, and is simply the distance light travels in a year, the speed of light being 186,000 miles per second. Expressed in figures it gives 5,785,344,000,000 as the distance in miles that light travels in one year. When it is added that (61) Cygni, the nearest star to the earth in the northern hemisphere, is nearly six light years

away, some idea of the profundity of space is made manifest.

The following symbols are used in the diagrams:

○ The outlined circle to indicate the double stars.

+ The cross to indicate the position of the nebulæ.

⁂ The group of dots to show the location of the star clusters.

The following abbreviations appear in the text:

A., Angle; D., Distance; H., Herschel; Mg., Magnitude; M., Messier; Σ, Wm. Struve; OΣΣ, Poulkova Catalogue, Part II; P., Piazzi Smyth; OΣ, Otto Struve.

In the compilation of this book I desire to acknowledge my indebtedness to Mr. Garrett P. Serviss, the author of *The Moon* and *Pleasures of the Telescope*. These books have been a positive inspiration to me, and the student is urged to include them in his collateral reading.

Mr. Serviss, than whom no one has done more to popularize the charming study of the stars, has the wonderful gift of imparting knowledge through the medium of a style that is altogether fascinating, and I take great pleasure in adding my mite of tribute to one who has afforded me through his numerous writings so many hours of unalloyed pleasure.

In preparing the list of objects suitable for observation, I derived much valuable information also from the following books:

*Celestial Objects for Common Telescopes*.....Webb
*Half Hours with the Telescope*.....Proctor
*Hours with a Three-inch Telescope*.....Noble
*Popular Telescopic Astronomy*.....Fowler
*Astronomy with the Naked Eye*.....Serviss
*The Moon*,.....Proctor
*The Friendly Stars*.....Mrs. Martin
*Klein's Star Atlas.*
*Ball's Atlas of Astronomy.*
*The Nautical Almanac.*

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# THE CONSTELLATIONS OF SPRING

## CANCER AND CANIS MINOR

| DOUBLE STAR | MAGNITUDES | DISTANCE | ANGLE | REMARKS |
|---|---|---|---|---|
| $\iota$ | $4\frac{1}{2}$–$6\frac{1}{2}$ | 30″ | 308° | Yellow, blue. Good contrast. |
| $\Sigma$1223 | 6–6 | 5″ | 214° | |
| $\upsilon'$ | 6–7 | 6″ | 37° | |
| $\zeta$ | 5.0–5.7 | 0.7 | | Only two stars can be seen with three-inch glass. |
| triple | 6–7–7 | 5.7″ | 114° | |
| $\Sigma$1311 | 7–7 | 7″ | 200° | |
| $\theta$ | $5\frac{1}{2}$–9 | 61″ | | |
| 66 | 6–9 | 4.8″ | 136° | Use 160 power. |
| $\phi^2$ | 6–$6\frac{1}{2}$ | 5″ | 212° | |
| 64 | $5\frac{1}{2}$–9 | 89″ | 294° | |
| 93 Lyncis | 6–8 | 75″ | 168° | Gold, azure. |
| $\Sigma$1245 Hydræ | 6–7 | 10″ | 25° | |
| 14 | 6–7–8 | 115″ | 154° | In Canis Minor. |
| Triple | | 75″ | 65° | |

Observe the "Bee Hive" with a low power. It contains 363 stars.

Note the cluster 1712 (67 M.). Herschel observed more than 200 stars in the field of view at once.

An occultation of ($\gamma$) by the moon frequently occurs. See List of Occultations, page —.

($\iota$) was discovered to be double by Herschel, 1782. Because of the much anticipated reappearance of Halley's comet in 1910, it is an interesting fact that this comet was first observed in Cancer in 1531.

Observe Castor, that gem of double stars in Gemini.

Procyon, a star of the solar type, has a 10th magnitude companion, green in color, 281″ distant. It is 12 light years distant, and has a proper motion of 13 miles per second. It is not definitely known whether it is approaching or receding from the earth.

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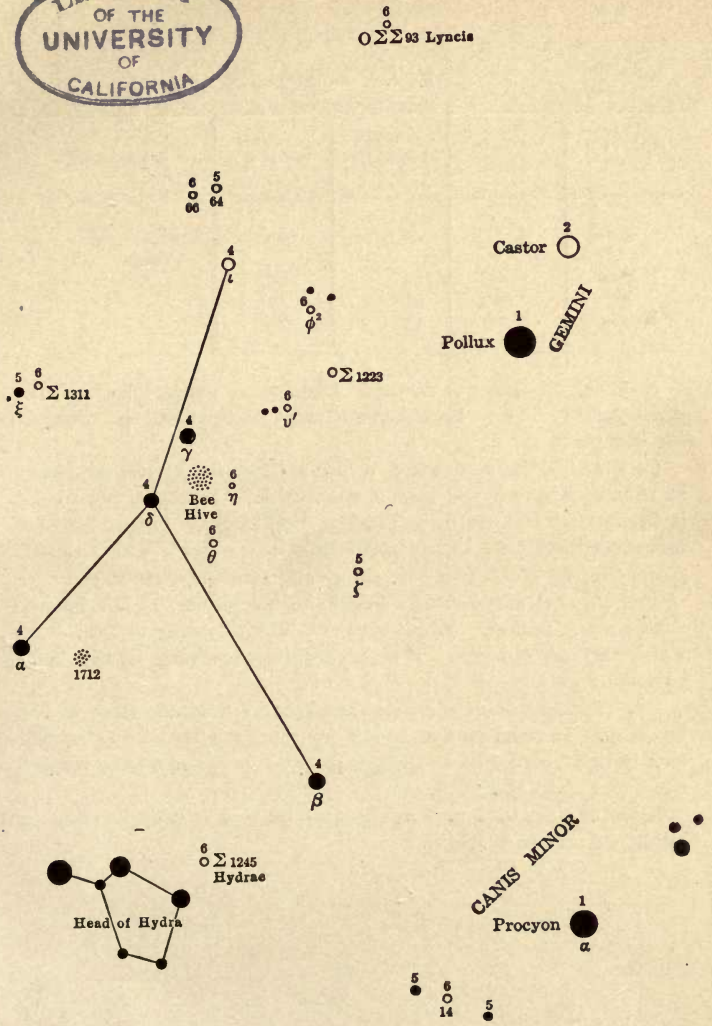



Gemini Page 75
Leo Page 13

## CORONA BOREALIS

| DOUBLE STAR | MAGNITUDES | DISTANCE | ANGLE | REMARKS |
|---|---|---|---|---|
| $\zeta$ | 4–5 | 6.3″ | 300° | White, blue, or green. |
| $\sigma$ | 5–6 | 4″ | 206° | |
| $\lambda$ | 6–7 | 95″ | 57° | |
| $\Sigma$1964 | 7–7½ | 15″ | 86° | |

Note ($\nu$), a naked eye double. Distance, 6′. angle, 165°. Both deep yellow. They both have a faint companion too difficult for our glass.

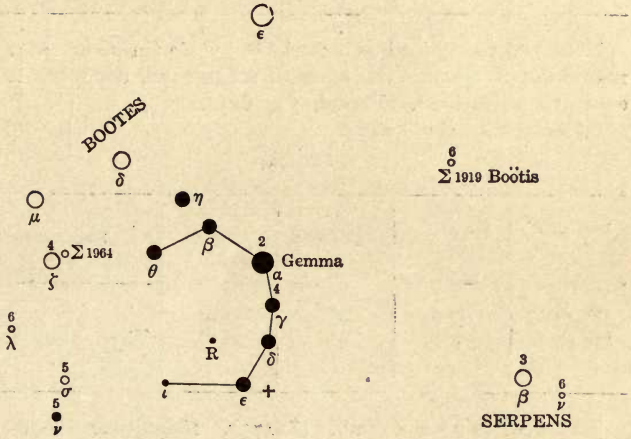
(+) marks the spot where a famous temporary star appeared in 1866 as a star of the second magnitude. In about two weeks it declined to the ninth, its present magnitude. It was the first temporary star to which spectroscopic analysis was applied. According to Webb this star should be carefully watched.

The star ($\eta$) is too close a double for our glass. It is a binary with a short period. Webb says, "It is interesting to look at so wonderful an object as a pair of suns revolving in the brief period of 41.5 years."

"R" marks one of the most remarkable variable stars in the heavens. It remains sometimes for a year without any alteration in light, sometimes falling rapidly. It varies from a magnitude of 5.8 to the 13th.

Note the doubles in Serpens and Boötes in this locality as indicated on the diagram.

## CORONA BOREALIS




Serpens Page 27
Bootes Page 21
Hercules Page 11

## CORVUS AND CRATER

### Corvus

| DOUBLE STAR | MAGNITUDES | DISTANCE | ANGLE | REMARKS |
|---|---|---|---|---|
| δ | 3–8 | 24″ | 211° | Yellow, purple. Fine contrast. |
| Σ1669 | 6½–6½ | 5″ | 299° | |

Note (R) recognized as a variable by Karlinski in 1867. At maximum it reaches the seventh magnitude, declining to the eleventh magnitude. Period, 319 days.

Observe the nebula 4361.

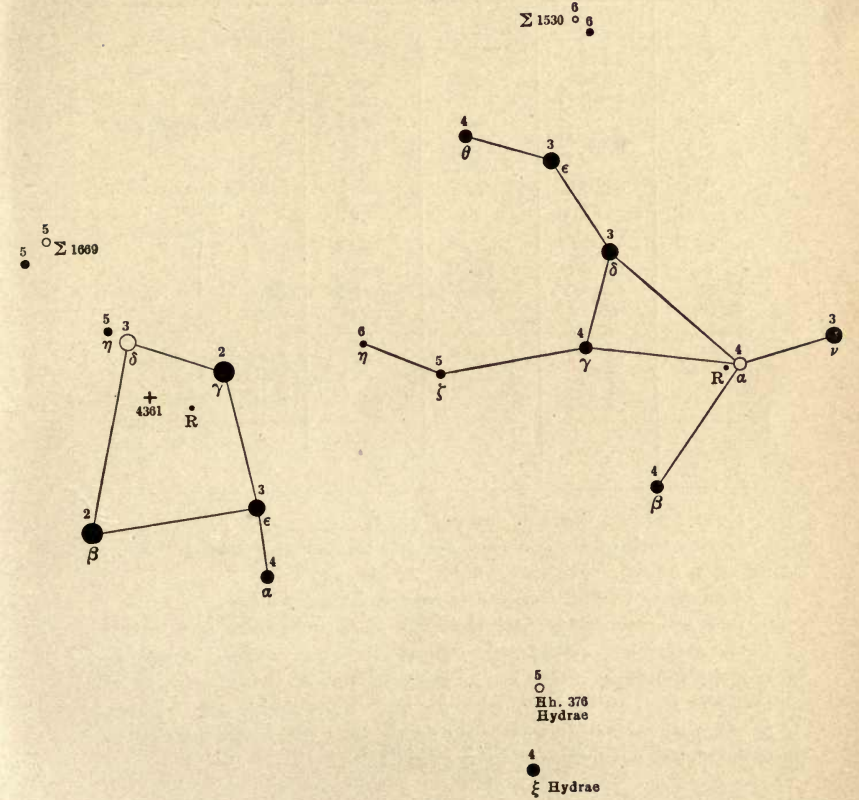
### Crater

| DOUBLE STAR | MAGNITUDES | DISTANCE | ANGLE | REMARKS |
|---|---|---|---|---|
| Σ1530 | 8–8 | 7″ | 314° | |
| H. 376 | 5½–7 | 8″ | 211° | This star is in Hydra. |

Just west of (ν) is a double (Σ1473). Magnitudes, 8–9. Distance, 30″. Angle, 10°.

21′ north is (1474). Magnitudes, 7–8. Distance, 71″. Angle, 22°.

A line drawn from (γ), to (α), prolonged a little over its length, locates a remarkable planetary nebula in Hydra (Herschel 27). "It will be seen like a pale blue disk, like the ghost of Jupiter." It is just south of the fourth magnitude star (μ) Hydræ.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Hh. 376
Hydrae
4
ξ Hydrae

| DOUBLE STAR | MAGNITUDES | DISTANCE | ANGLE | REMARKS |
|---|---|---|---|---|
| $\nu$ | 5–5 | 62″ | 312° | A grand object. |
| $\Psi$ | 4–5 | 31″ | 15° | |
| 40,41 | 5–6 | 20″ | 235° | |
| 39 | 5–8½–7 | 3.6″ | 360° | Very fine. |
| Triple | | 90″ | 22° | White, blue, red. |
| 17 | 6–6½–6 | 3.8″ | 116° | |
| Triple | | 90″ | 195° | A fine sight. |
| o | 4½–7½ | 31″ | 341° | Orange, emerald. |
| $\epsilon$ | 5–8 | 3″ | 5° | Red, blue. Good contrast. |
| $\iota$ | 3–9 | 255″ | 50° | |
| $\gamma$ | 2½–11 | 125″ | 116° | |
| $\Sigma$1984 | 6½–8½ | 6.4″ | 276° | |
| $\Sigma$2604 | 6½–8½ | 27″ | 184° | |
| $\Sigma$2573 | 6–8½ | 18″ | 29° | |
| O$\Sigma\Sigma$123 | 6½–7 | 68″ | 147° | A striking object. |
| $\Sigma$2348 | 6–8 | 25″ | 272° | Yellow, blue. |
| $\mu$ | 5–5 | 2.4″ | 158° | Both white. A beautiful miniature of Castor. |

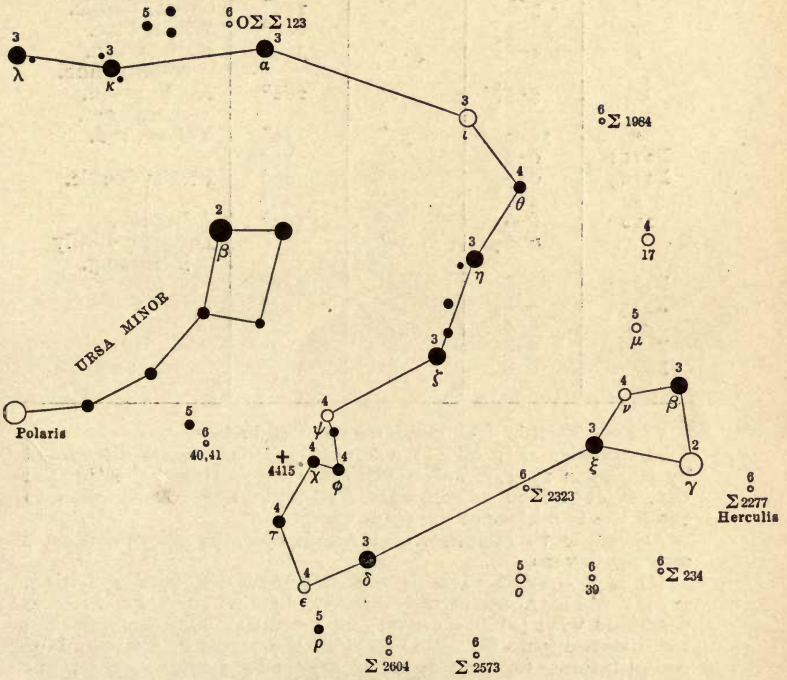
Note Tuttle's variable nebula 4415.

Look south of ($\lambda$) a degree for the double star $\Sigma$2573. Magnitudes, 6½–7½. Distance, 69″. Angle, 147°.

According to Flammarion (o) is an optical double.

It is an interesting fact that the stars which are not visible to the eye give more light than those which are visible. Approximately speaking, there are 20 stars of the 1st magnitude, 60 of the 2d, 180 of the 3d, and so on. Multiplying the number of stars of each successive magnitude by 3 gives the number of stars of the next fainter magnitude.

# DRACO





Hercules Page 11
Ursa Major Page 35
Lyra Page 15

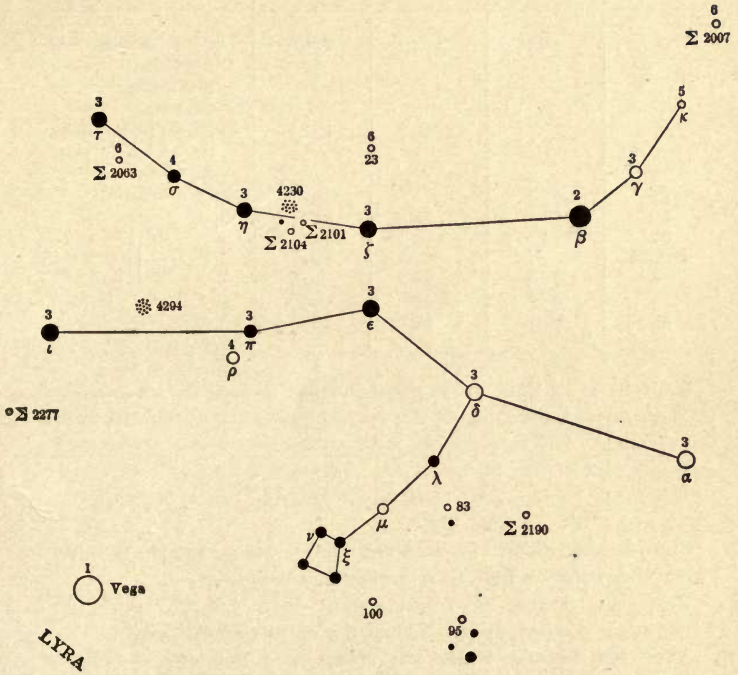
| DOUBLE STAR | MAGNITUDES | DISTANCE | ANGLE | REMARKS |
|---|---|---|---|---|
| $\alpha$ | 3–6 | 4.7″ | 118° | Orange, green. Good contrast. |
| $\delta$ | 3–8 | 19″ | 175° | Green, purple. |
| $\gamma$ | 3½–9 | 38″ | 242° | White, lilac. |
| $\rho$ | 4–5½ | 3.7″ | 309° | Both green, coloring fine. |
| 95 | 5–5½ | 6″ | 262° | Apple green, cherry red. |
| $\kappa$ | 5½–7 | 31″ | 10° | Yellow, red. |
| $\Sigma$2101 | 6–9 | 4″ | 57° | |
| $\Sigma$2104 | 6–8 | 6″ | 20° | Pretty double. |
| $\mu$ | 4–9½ | 30″ | 241° | |
| 100 | 6–6 | 14″ | 182° | A beauty. |
| 83 | 6–8½ | 16″ | | Distance slowly increasing. |
| $\Sigma$2007 | 6½–8 | 32″ | 328° | |
| $\Sigma$2190 | 6–8½ | 10″ | 23° | |
| 23 | 6–9 | 34″ | 18° | |
| $\Sigma$2063 | 6–8 | 16″ | 194° | |
| $\Sigma$2277 | 6–8 | 28″ | 117° | |

For the double (m) Hercules see Ophiuchus.

The cluster 4230 (M.13), a superb globular cluster discovered by Halley in 1714, is well worth observing. Herschel estimated that it contained 14,000 stars. It takes a four-inch glass to catch the twinkling of the stars.

According to Herschel and Argelander the solar system is moving toward ($\lambda$).

($\delta$) is a colored variable and one that will bear watching. ($\alpha$) is a red star, one of the type with banded spectra. A circle described with ($\mu$) as a centre and a radius a little greater than the distance from ($\mu$) to ($\lambda$) includes the result of five standard computations for the apex of the solar system,—the point toward which the sun and all the planets are speeding at the rate of 14½ miles per second.




Lyra Page 15
Draco Page 9
Corona Borealis Page 5
Ophiuchus Page 27

| DOUBLE STAR | MAGNITUDES | DISTANCE | ANGLE | REMARKS |
|---|---|---|---|---|
| $\gamma$ | 2–4 | 3·7″ | 118° | Finest double in northern sky, according to Struve. |
| $\tau$ | 5–7 | 95″ | 170° | Lemon, light blue; a second pair in the field (83) |
| 54 | 4½–7 | 6″ | 102° | A fine sight. |
| 93 | 5–8 | 74″ | 356° | |
| 90 | 6–7½–10 | 3·5″ | 209° | |
| Triple | | 50″ | 204° | |
| 6 | 6–9 | 38″ | 74° | |
| 7 | 6–8 | 42″ | 356° | |
| 88 | 7–9 | 15″ | 320° | |

Regulus is 35 light years distant from the earth. According to Huggins it is receding at the rate of twelve to seventeen miles per second. It has a proper motion of eight miles per second, and is a star of the Sirian type. There is a distant companion to Regulus, "seemingly steeped in indigo," says Miss Clerke. Distance, 176″. Angle, 306°.

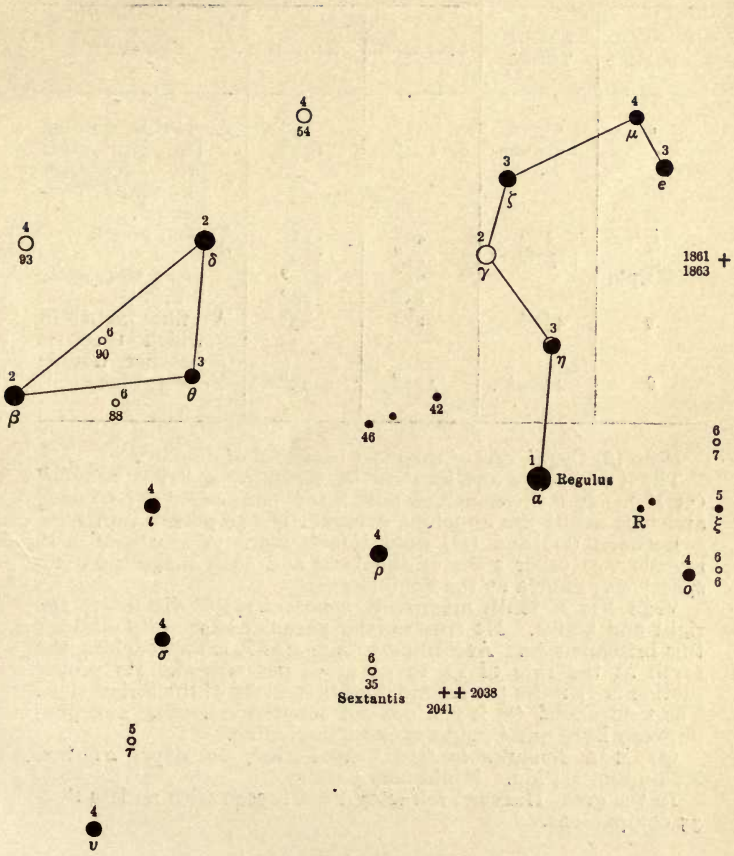
The variable (R) is of a deep red color. Its period is 312 days, and it fades from a fifth to a tenth magnitude star.

Note the double (35) Sextantis. 6–7. D., 6″. A., 240°.

($\beta$) has a distant companion of the eighth magnitude.

Note the nebula 1861–1863, large and brilliant, a double nebula in powerful telescopes.

($\gamma$) is one of the doubles best observed when it is not quite dark or in moonlight. The colors of the stars are yellow and green.




Cancer Page 3
Virgo Page 17

## LYRA

| DOUBLE STAR | MAGNITUDES | DISTANCE | ANGLE | REMARKS |
|---|---|---|---|---|
| $\epsilon$ | $\epsilon^1$ 5–6 | 3″ | 15° | A double double. |
| | $\epsilon^2$ 5–6 | 2.3″ | 133° | The four stars are doubtless physically connected. |
| $\zeta$ | 4–6 | 44″ | 150° | Topaz, green. |
| $\beta$ | 4–7–8–11 | 45″ | 150° | The four stars |
| Multiple | | 65″ | 320° | form the letter |
| | | 85″ | 20° | "Y." |
| $\eta$ | 4½–8 | 28″ | 85° | A fine field in which there is another double |
| $\theta$ | 4½–9½ | 101″ | 70° | Yellow, blue. |

Note ($\beta$) Cygni, one of the most beautiful of doubles.

The (+) marks the location of the famous "ring nebula" (57 M.). In a three-inch glass it has a dim, misty appearance, and it is about the apparent diameter of the planet Jupiter.

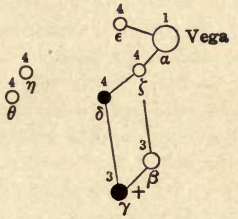
Between ($\epsilon^1$) and ($\epsilon^2$) note a faint star. A four-inch glass reveals two other stars of the 12th and 13th magnitudes respectively, known as the debillissima.

Vega has a tenth magnitude companion 48″ distant to the right and above. No trustworthy parallax has been found for this brilliant star. According to Huggins it is approaching the earth at the rate of 44 to 54 miles per second. Its proper motion is 31 miles per second, and it is a star of the Sirian type. The field about ($\delta$) is glorious for low powers. The sweeping between Lyra and Cygnus is exceedingly fine.

($\beta$) is a remarkable variable. Period, 12 days, 21 hrs. Maximum, 3.4 Mg. Minimum, 4.3 Mg.

In the great Harvard refractor Vega is seen with no less than 35 companions.

# LYRA




3
β Cygni


Cygnus Page 59
Hercules Page 11
Aquila Page 45
Draco Page 9

## VIRGO

| DOUBLE STAR | MAGNITUDES | DISTANCE | ANGLE | REMARKS |
|---|---|---|---|---|
| $\gamma$ | 3–3 | 5.8″ | 150° | Both yellow. A beautiful object. |
| Σ1669 | 6–6 | 5.6″ | 124° | A fine pair. |
| $\tau$ | 4–8½ | 79″ | 290° | |
| Σ1627 | 6–6 | 20″ | 196° | |
| Σ1682 | 6½–9 | 34″ | 309° | Yellow, red. |
| $\theta$ | 4½–9–10 | 7″ | 345° | |
| Triple | | 65″ | 295° | |

Many nebulæ are to be seen in the bowl-shaped region formed by the stars ($\beta$), ($\eta$), ($\gamma$), ($\delta$), ($\epsilon$), which is called "The Field of the Nebulæ." Use about 40 power.

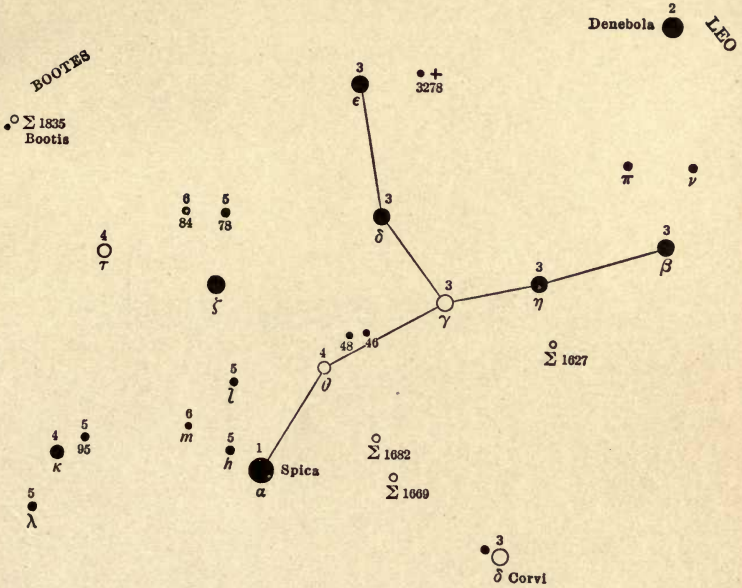
($\gamma$) is a variable double. Each star in turn declines about half a magnitude, and recovers within a few days. In 1756 the distance between the components was 6″. In 1836 the two stars were so close together that they could not be split with the largest telescopes. Now the stars are 5.8″ apart, and the distance between them is widening. ($\gamma$) is best observed in the twilight or moonlight. Its period of revolution is 180 years.

Spica is of the Sirian type of stars, and is approaching the earth at the rate of from 9 to 14 miles per second.

The (+) locates the nebula 3278. Webb says it resembles a paper kite, and that it is beautifully grouped with three stars. There are two nebulæ in the field.

The stars ($\nu$), (46), (48), (l), (m), (95), ($\kappa$), and ($\lambda$) are frequently occulted by the moon.

# VIRGO





Leo Page 13
Bootes Page 21
Libra Page 25
Corvus and Crater Page 7

# THE CONSTELLATIONS OF SUMMER

## BOÖTES

| DOUBLE STAR | MAGNITUDES | DISTANCE | ANGLE | REMARKS |
|---|---|---|---|---|
| $\pi$ | 4–6 | 6″ | 99° | Both white. |
| $\delta$ | $3\frac{1}{2}$–$8\frac{1}{2}$ | 110″ | 75° | Yellow, blue. |
| $\mu$ | 4–7 | 108″ | 172° | |
| 44 | 5–6 | 4.8″ | 240° | A binary. Period, 261 years. |
| 39 | 6–6 | 3.6″ | 45° | Good contrast of colors. |
| $\iota$ | $4\frac{1}{2}$–$7\frac{1}{2}$ | 38″ | 33° | Yellow, white. |
| $\kappa$ | $5\frac{1}{2}$–8 | 12″ | 238° | White, blue. A beautiful object. |
| $\Sigma$1919 | 6–7 | 25″ | 10° | Yellow, white. |
| $\Sigma$1850 | 6–7 | 26″ | 262° | Yellow, blue. |
| $\Sigma$1835 | $5\frac{1}{2}$–7 | 6″ | 186° | |
| $\xi$ | 5–7 | 3″ | 200° | Yellow, purple. Fine contrast. |
| $\epsilon$ | $2\frac{1}{2}$–6 | 2.8″ | 326° | Orange, green. A superb sight. |

Arcturus is approaching the earth at the rate of 45 miles per second. "Its excessive remoteness (Peters gives 25 light years) enables us to recognize in it perhaps the most stupendous sun within our imperfect cognizance." It has a proper motion of 372 miles per second, is a star of the solar type, and has a distant companion of a pale lilac color. In brilliance it is equal to 5000 suns like ours.

The components of ($\zeta$) are rapidly narrowing. In a few years only the most powerful telescopes can split it.

($\epsilon$) was called "Pulcherrima" by Smythe on account of its extreme beauty. A power of 160 is recommended.

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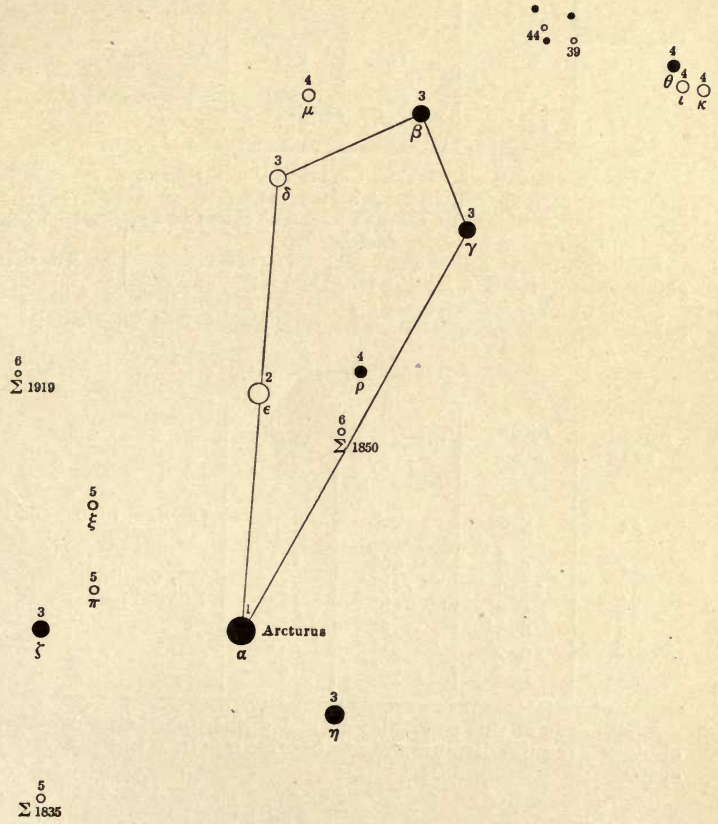
# BOÖTES

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Corona Borealis Page 5
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## CANES VENATICI

| DOUBLE STAR | MAGNITUDES | DISTANCE | ANGLE | REMARKS |
|---|---|---|---|---|
| α Cor Caroli | 3–6 | 20″ | 227° | Both yellow. |
| 2 | 6–8 | 11″ | 260° | Red, blue. Fine contrast. |
| Σ1615 | 6–8 | 26″ | 88° | Yellow, ashy. |
| 15 | 5½–6 | 290″ | 297° | |

7° north-northwest of Cor Caroli is "La Superba," a 5th magnitude star of brilliant red color. It is one of the seven or eight naked eye stars of the 4th spectral class, and is noted for the brilliant coloring of its flashing rays.

Webb describes the cluster 3636 as a brilliant and beautiful globular congregation of not less than 1000 small stars.

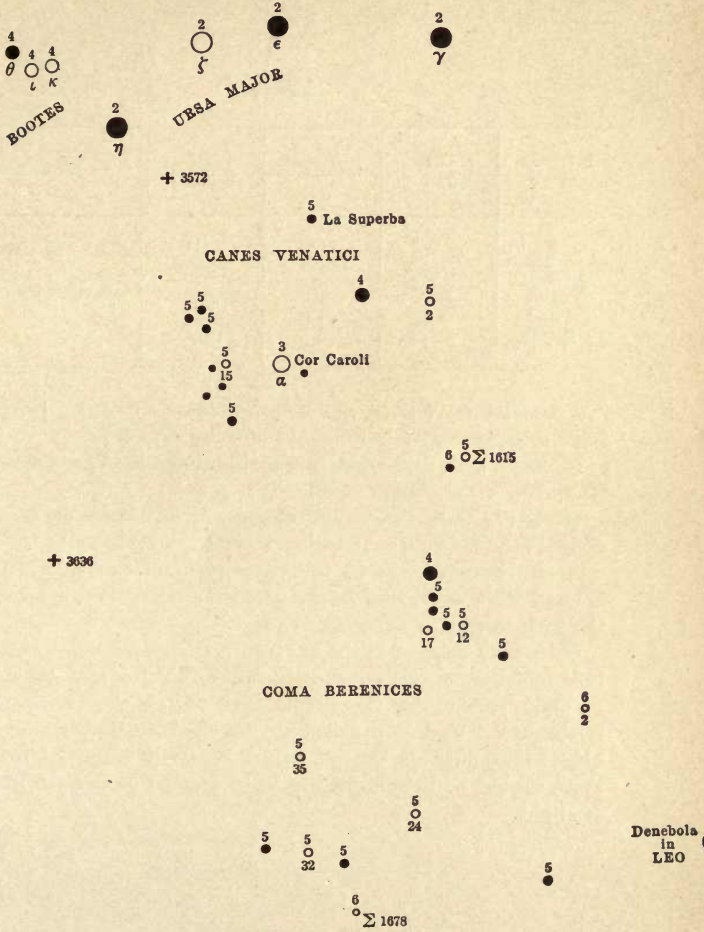
South of "La Superba" is a fine pair of 7th Mg. stars. The nebula 3572 is the "Spiral or Whirlpool Nebula" of Lord Rosse.

## COMA BERENICES

| DOUBLE STAR | MAGNITUDES | DISTANCE | ANGLE | REMARKS |
|---|---|---|---|---|
| 24 | 5–6 | 20″ | 270° | Orange, lilac. Fine contrast. |
| 12 | 5–8 | 66″ | 168° | |
| 17 | 5½–6 | 145″ | 250° | White, lilac. |
| 35 | 5–9 | 28″ | 124° | Lilac, blue. |
| 2 | 6–6½ | 3.6″ | 24° | |
| Σ1678 | 6–7 | 32″ | 211° | |
| 32 | 5–6 | 194″ | 48° | |

Webb says of this constellation, "A gathering of stars which obviously require distance only to become a nebula to the naked eye."

## CANES VENATICI AND COMA BERENICES





Ursa Major Page 35
Bootes Page 21
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## LIBRA

| DOUBLE STAR | MAGNITUDES | DISTANCE | ANGLE | REMARKS |
|---|---|---|---|---|
| ι | 4½–9 | 57″ | 110° | Fine contrast. |
| 212 P. | 6–7½ | 15″ | 290° | |
| Σ1962 | 7–7 | 12″ | 189° | Pretty object. |
| H. 4783 | 6–9 | 11″ | 232° | |
| 54 Hydræ | 6–7½ | 9″ | 129° | |

According to Wilson 212 P. resembles 61 Cygni. Both stars have a large proper motion in the same direction.

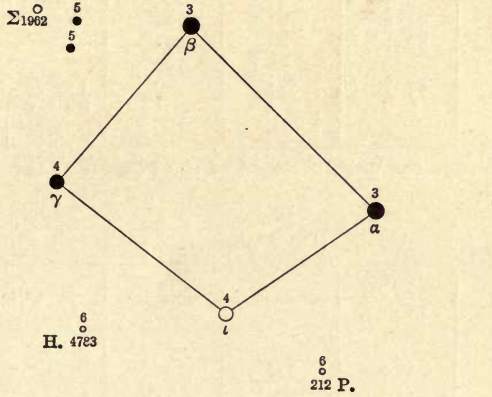
(α) has a fifth magnitude companion visible in an opera-glass. Magnitudes 3–6, colors yellow, light gray.

(β) is the only naked eye star green in color. It is a wide double for a field-glass. Colors, emerald, light blue.

A line drawn from (ι) to (β) Libræ, and prolonged a little beyond its length, locates the cluster 4083 in Serpens, close to the fifth magnitude star (5) Serpentis.

Stars may be seen in the daytime with even a small telescope. It is said that a telescope of 1″ aperture will show stars of the 2d magnitude. For those who care to try the experiment, it is suggested that a planisphere be used to locate some such bright landmark as Orion's belt. When it is on the meridian there should be little difficulty in seeing the stars even in broad daylight.

# LIBRA




Scorpio Page 33
Virgo Page 17
Ophiuchus and Serpens Page 27

## OPHIUCHUS

| DOUBLE STAR | MAGNITUDES | DISTANCE | ANGLE | REMARKS |
|---|---|---|---|---|
| 67 | 4–8 | 55″ | 144° | Yellow, red. Fine contrast. |
| 36 | 5–7 | 4·3″ | 195° | Yellow, red. |
| $\tau$ | 5–6–9 | 100″ | 127° | |
| Triple | | | | |
| 39 | 6–7½ | 12″ | 356° | Yellow, blue. Fine contrast. |
| Σ2166 | 6–7½ | 27″ | 280° | White, bluish. |
| 61 | 5½–6 | 21″ | 94° | |
| 53 | 5½–7½ | 41″ | 191° | |
| 19 | 6–9 | 22″ | 93° | |
| 70 | 4½–7 | 5·5″ | 148° | Yellow, red. |
| $\rho$ | 6–6 | 4″ | 1° | Fine close pair. Yellow, blue. |

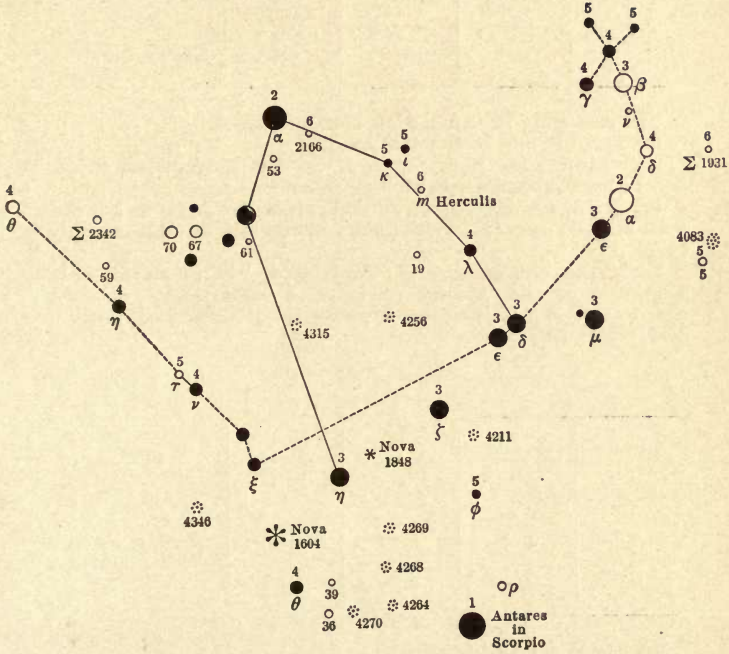
Webb says the neighborhood of the new star 1848 should be watched.

## SERPENS

(In dotted line.)

| DOUBLE STAR | MAGNITUDES | DISTANCE | ANGLE | REMARKS |
|---|---|---|---|---|
| $\delta$ | 3–4 | 3·5″ | 190° | Both white. A fine object. |
| $\theta$ | 4–4½ | 21″ | 104° | Both yellow. Lies in rich field. |
| $\nu$ | 5–9 | 50″ | 31° | Green, lilac. |
| $\beta$ | 3½–9 | 30″ | 265° | Blue, yellow. |
| 5 | 5–10 | 10″ | 41° | |
| Σ2342 | 6–8 | 26″ | 120° | |
| Σ1931 | 6–7½ | 13″ | 172° | |

Observe the cluster 4083 close to (5)
(70) Ophiuchi and ($\nu$) Serpentis are colored variables.
Note (m) Herculis. Mg., 6–8. D., 69″. A., 230°.




Hercules Page 11
Scorpio Page 33
Sagittarius Page 31

## SAGITTA

| DOUBLE STAR | MAGNITUDES | DISTANCE | ANGLE | REMARKS |
|---|---|---|---|---|
| $\epsilon$ | 6–8 | 92″ | 81° | |
| 13 | 6–7½ | 340″ | 13° | |
| $\theta$ | 7–9–8 | 11″ | 327° | |
| Triple | | 70″ | 227° | |
| $\zeta$ | 5–9 | 8.6″ | 312° | Green, blue. |

The sweeping in this region is magnificent.

($\alpha$) and ($\beta$) are both wide doubles.

(15) commands a fine group. A few minutes north of it, is a beautiful star, sapphire blue in color.

($\eta$) lies in a rich region. A circle around it of 30′ or 40′ radius will include several very pretty little 8th or 9th magnitude pairs.

Note the cluster 4520. Webb says, "It is an interesting specimen of the process of nebular resolution." About 1° south of it is a beautiful low power field containing faint pair and triple groups.

## DELPHINUS

| DOUBLE STAR | MAGNITUDES | DISTANCE | ANGLE | REMARKS |
|---|---|---|---|---|
| $\gamma$ | 4–5 | 11″ | 273° | Golden, emerald. Fine contrast. |
| $\alpha$ | 4–9 | 35″ | 278° | |

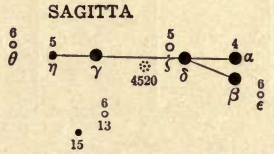
($\theta$) lies in a beautiful field.

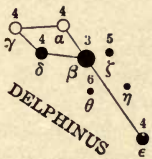
There is a pretty pair in the field with ($\epsilon$).

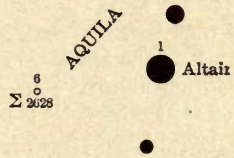
Just S. W. of ($\zeta$) is a triple of 7½ magnitude stars.

Note Σ2628 Aquilæ. Mg., 6–6. D., 60″. A., 175°.

## SAGITTA AND DELPHINUS




Aquila Page 45
Cygnus Page 59
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## SAGITTARIUS

| DOUBLE STAR | MAGNITUDES | DISTANCE | ANGLE | REMARKS |
|---|---|---|---|---|
| 54 | 6–7½ | 45″ | 42° | Yellow, blue. |
| μ | 3½–9½–10 | 40″ | 315° | |
| Triple | | 45″ | 114° | |
| Σ2325 | 6–9 | 12″ | 257° | This double and the one following are in Sobieski's Shield. |
| Σ2306 | 7–8 | 12″ | 219° | Yellow, blue. A beautiful object. |

There are many fine star clusters and nebulæ in this region. Note especially the clusters M. 22, M. 24, M. 25. They are all visible to the naked eye, and the former has been known since 1665. Observe the so-called "Trifid Nebula" 4355 (M. 20), also 4403 (M. 17) known as the "Horse-shoe Nebula," one of the nebula that can be observed with comparatively low optical power. Huggins has shown it to be gaseous.

M. 18 is in a glorious field. "A region of surpassing splendor."

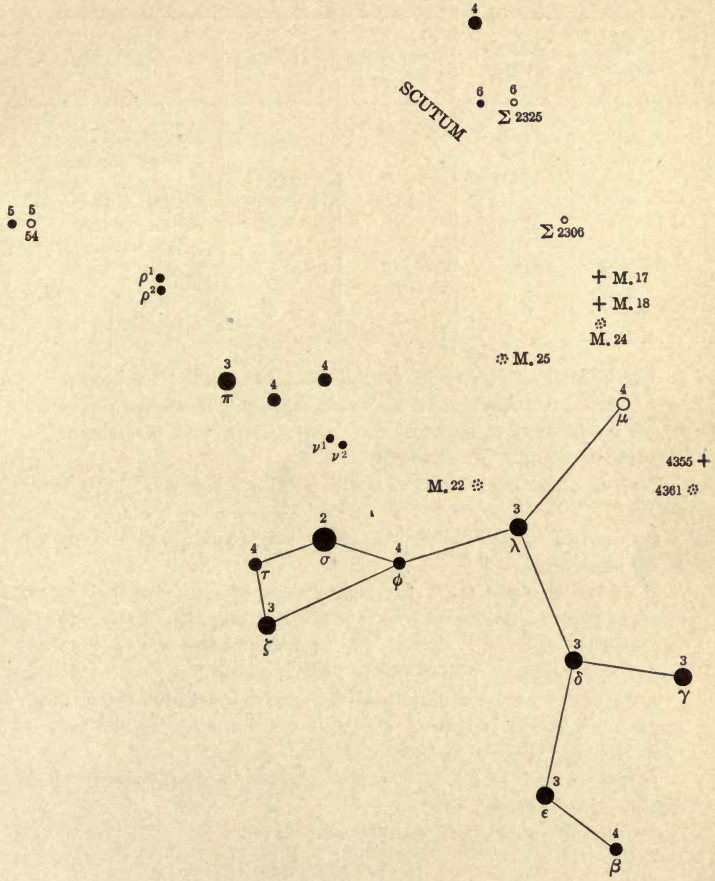
About 1¼° south of (λ) is a fine seventh magnitude triangle.

It is seldom that more than 2000 stars are visible together to the naked eye up to the 6th magnitude.

Using a telescope of only 2½-inch aperture Argelander registered 324,189 stars down to the 9½ magnitude.

When the photographic charting of the sky is accomplished about 650,000 stars will be identified and indexed.

According to Newcomb, the total number of the stars is to be counted by hundreds of millions.

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Scorpio Page 33
Aquila Page 45

## SCORPIO

| DOUBLE STAR | MAGNITUDES | DISTANCE | ANGLE | REMARKS |
|---|---|---|---|---|
| $\beta$ | 2–6 | 13″ | 30° | White, bluish. Fine contrast. |
| $\nu$ | 4–7 | 40″ | 336° | |
| $\sigma$ | 4–9 | 20″ | 272° | White, blue. |
| $\xi$ | 5–7 | 7″ | 65° | White, gray. Beautiful field. |
| P. 236 | 6½–8 | 4″ | 231° | A pretty pair. |
| $\rho$ Ophiuchi | 6–6 | 4″ | 1° | |

The cluster 4264 in Ophiuchus was discovered by Messier in 1764, and catalogued as a nebula. In 1784 Herschel proved it to be a globular cluster. The cluster 4268 was discovered by Herschel. It is 2′ in diameter.

4270 is a globular cluster, fairly brilliant, followed by a faint nebula.

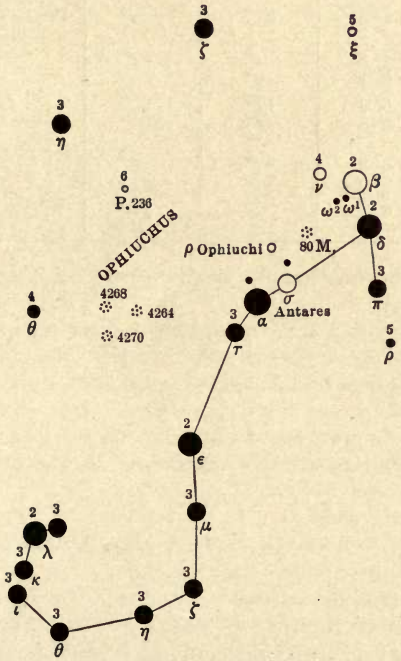
($\nu$) Scorpii is said to be the most beautiful quadruple group in the heavens.

Herschel thought that the cluster 4173 (80 M.) was the richest mass of stars in the heavens. On the eastern side of this cluster is a starless spot, a "black hole," similar to the so-called "coal sack" in Cygnus. Webb likens it to a comet.

Antares has a companion of the 7½ magnitude, distant 3″, angle 270°, green in color. Proctor says a larger glass than a four-inch is required to split it.

A little south of ($\xi$) is a double, $\Sigma$1999. Magnitudes, 7½–8, distance, 10″, angle, 103°.

($\beta$) may be an optical double.




Ophiuchus Page 27
Libra Page 25
Sagittarius Page 31

| DOUBLE STAR | MAGNITUDES | DISTANCE | ANGLE | REMARKS |
|---|---|---|---|---|
| $\zeta$ | 2–4 | 14″ | 148° | Both white. Alcor in the same field. |
| 23 | 4–9 | 23″ | 272° | Fine contrast of colors. |
| $\sigma^2$ | 5–8 | 4″ | 263° | |
| 57 | 6–8 | 5″ | 4° | |
| $\Sigma$1415 | 6–7 | 16″ | 167° | |
| $\Sigma$1561 | 6–8 | 10″ | 266° | "Prettily grouped." |
| $\Sigma$1495 | 6–8 | 35″ | 38° | |
| $\Sigma$1520 | 6½–8 | 13″ | 345° | |
| 65 | 6–8 | 4″ | 38° | White, blue. |

Note the two fine nebulæ separated by only half a degree, 1949 and 1950.

2343 (M. 97) is a large planetary nebula called "The Owl Nebula." South of the so-called "Spiral Nebula" in Canes Venatici, is the beautiful and easy double Cor Caroli.

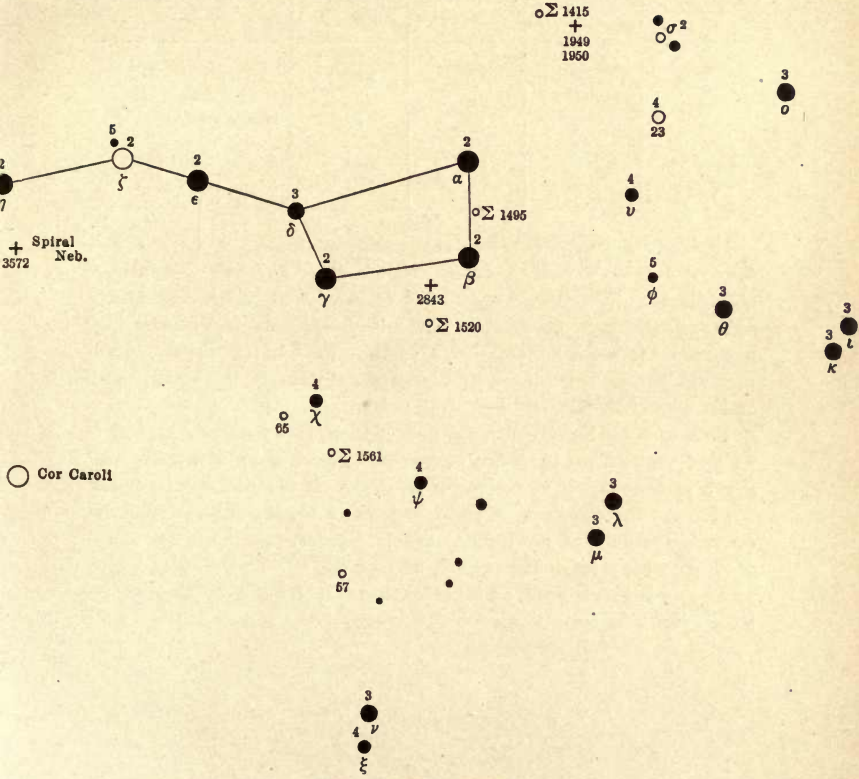
($\zeta$) is probably the best known double star in the heavens, and is one of the most beautiful. It is easy to find, and is most effective to view in a small telescope. It was discovered by Riccioli.

($\gamma$) lies in a fine field.

The stars ($\beta$) ($\gamma$), ($\delta$), ($\epsilon$), and ($\eta$) are all stars of the Sirian type. ($\alpha$) is a star of the solar type.

($\zeta$) and ($o$) are spectroscopic binaries. The former was the first double photographed by Bond.

A third star is in the field with (65); D., 62″. A., 113°.

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Ursa Minor Page 37
Draco Page 9
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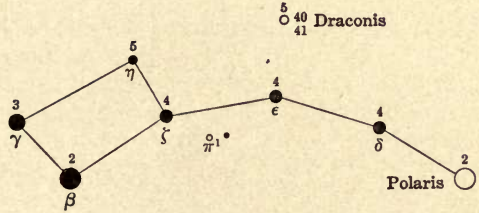
## URSA MINOR

| DOUBLE STAR | MAGNITUDES | DISTANCE | ANGLE | REMARKS |
|---|---|---|---|---|
| $\alpha$ | 2–9 | 18″ | 210° | Yellowish-white and blue. |
| $\pi^1$ | 6–7 | 30″ | 83° | Both yellow. |
| 40, 41 Draconis | 5–6 | 20″ | 235° | A fine double. |
| OΣ 262 | 7–8 | 28″ | 182° | |

If your glass is a good one and the atmospheric conditions are favorable, you should have no trouble in seeing the companion to Polaris. Webb states that it is easy with anything much exceeding 2 inches. If it is difficult to see, try the method of inverted vision, or gazing at a distant part of the field. This method brings into use a more sensitive part of the retina and often succeeds admirably.

Polaris is 63 light years distant (Peters gives 35 years), has a proper motion of 2½ miles per second, and is approaching the earth at the rate of 16 miles per second. It is a star of the Solar type. At the distance of Polaris our sun would appear with an opera-glass as a 7½ magnitude star. Polaris is one of the spectroscopic binaries. Its period is 3.97 days. The star (40, 41) Draconis is given here, as its situation renders it easy to observe when the telescope is directed towards Ursa Minor.



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Draco Page 9
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# THE CONSTELLATIONS OF AUTUMN

## ANDROMEDA AND TRIANGULUM

### Andromeda

| DOUBLE STAR | MAGNITUDES | DISTANCE | ANGLE | REMARKS |
|---|---|---|---|---|
| $\gamma$ | 3–6 | 10″ | 62° | Yellow, blue. |
| $\Sigma 79$ | 6–7 | 7″ | 192° | Very beautiful. |
| $\pi$ | 4–8 | 36″ | 173° | Yellow, blue. |
| 56 | 6–6 | 181″ | 301° | |
| 59 | 6–7 | 16″ | 34° | Yellow, blue. |
| $\Sigma 3$ | $7\frac{1}{2}$–$8\frac{1}{2}$ | 5″ | 84° | |
| $\mu$ | 4–11 | 49″ | 110° | |

The " + " indicates the location of the great nebula which can be readily seen with the naked eye, and the only one which was discovered in pre-telescopic times. Its place was marked on a star map brought from Holland believed to date from the 10th century. It is known as "the transcendently beautiful queen of the nebulæ." It is a disappointing object in an ordinary telescope.

In Aug., 1885, a new star shone up in the very midst of the great nebula. It faded to invisibility during the next year. The distance of the nebula from the earth is so great as to render abortive all attempts to measure it with the most powerful instruments. Its dimensions doubtless are inconceivably enormous, and beyond comparison with those of the Solar System.

($\gamma$) is one of the most beautiful doubles in the heavens. It was first noticed by Mayer in 1788. The contrast of colors is very fine.

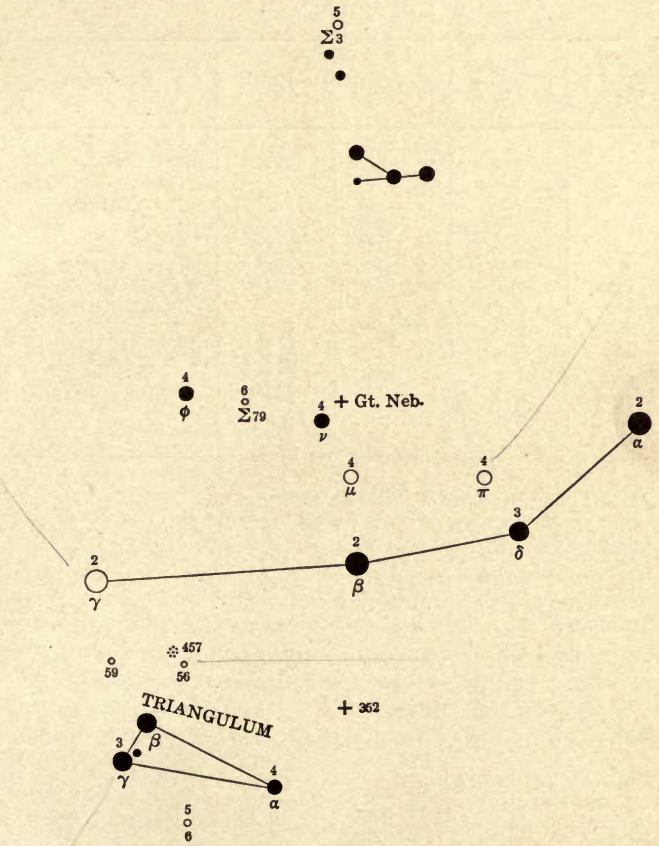
### Triangulum

| DOUBLE STAR | MAGNITUDES | DISTANCE | ANGLE | REMARKS |
|---|---|---|---|---|
| 6 | 5–7 | 3.8″ | 77° | Yellow, blue. An exquisite pair. |

Note the nebula 352 discovered by Messier. It is 30′ in extent.

The first asteroid to be discovered, Ceres, was discovered in Triangulum in 1801.

($\gamma$) is a fine naked eye triple.

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Perseus Page 63
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Cetus Page 57

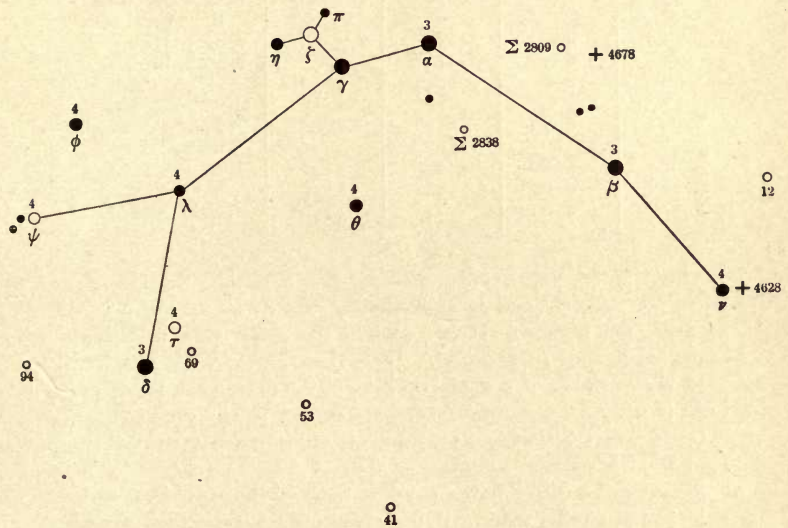
## AQUARIUS

| DOUBLE STAR | MAGNITUDES | DISTANCE | ANGLE | REMARKS |
|---|---|---|---|---|
| $\zeta$ | 4–4 | 3″ | 321° | Both green. Fine pair. Period 750 years. |
| 12 | 6–6 | 2.8″ | 190° | |
| 41 | 6–8 | 5″ | 115° | Yellow, blue. |
| $\tau$ | 6–9 | 27″ | 115° | White, garnet. |
| $\Psi$ | $4\frac{1}{2}$–8 | 50″ | 310° | Yellow, blue. Fine contrast. |
| 69 | 6–9 | 28″ | 115° | |
| 94 | 5–7 | 13″ | 345° | Fine contrast. |
| $\Sigma$2809 | 6–8 | 31″ | 163° | |
| $\Sigma$2838 | 6–8 | 21″ | 185° | |
| 53 | 6–6 | 7″ | 304° | |

For the double 107 Aquarii see Cetus.

Look for the nebula 4678, a beautiful round nebula discovered by Maraldi in 1764. A fine sight in a three-inch glass.

Just west of ($\nu$) is a fine specimen of a planetary nebula, 4628. It was discovered by Herschel in 1782. Rosse calls it the "Saturn nebula." It is moving toward the sun at the rate of 17 miles per second. Five degrees north and just east of ($\beta$) is 2 M., a large bright nebula; from it "streams of stars branch out, taking the direction of tangents." 1624 years is given for the period of ($\zeta$). About 4° east by south of ($\delta$) is 29, a fine double.




1 Fomalhaut

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Pisces Page 65
Pegasus Page 61
Capricornus Page 51



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## AQUILA

| DOUBLE STAR | MAGNITUDES | DISTANCE | ANGLE | REMARKS |
|---|---|---|---|---|
| 57 | 5–6 | 36″ | 170° | Yellow, green. Fine double. |
| 15 | 6–6 | 35″ | 206° | White, lilac. |
| 5 | 6–7 | 13″ | 121° | White, bluish. |
| 28 | 6–8 | 60″ | 175° | |
| 11 | 5½–9 | 18″ | 242° | Optical double. |
| Σ2644 | 6–7 | 3.6″ | 208° | Primary bluish, white. |
| Σ2654 | 6–8 | 12″ | 234° | |
| Σ2446 | 6–8 | 10″ | 154° | |
| Σ2628 | 6–8 | 4″ | 349° | Yellow, purple. |

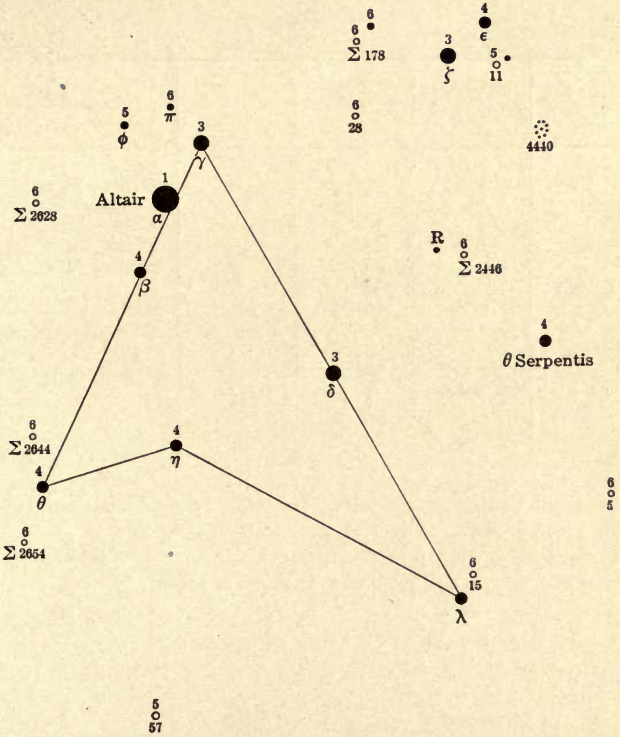
Altair is 16 light years distant, has a proper motion of 9 miles per second, and is approaching the earth at the rate of 27 miles per second. It is a star of the solar type, and has a tenth magnitude companion. Distance, 152″. Angle, 322°.

R. is a variable of a deep red color. At maximum its magnitude is 6½. At minimum, 11. Its period is 351 days.

(η) is a variable with maximum 3½, minimum 4.7 magnitude. Its period is 7 days, 4 hours.

Struve gave white as the color of both of the stars in (57).

Note the cluster 4440. A beautiful object consisting of stars of the ninth to the twelfth magnitudes.





| | |
|---|---|
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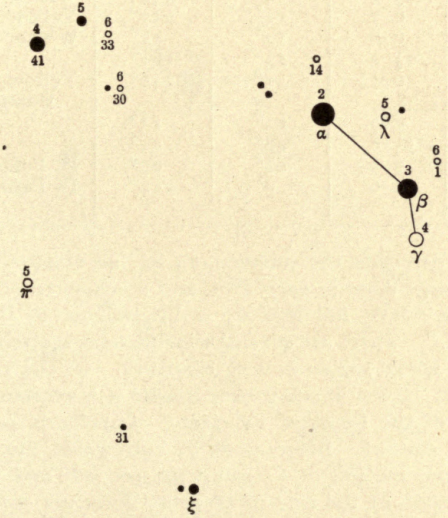
| Delphinus | Page 29 |

## ARIES

| DOUBLE STAR | MAGNITUDES | DISTANCE | ANGLE | REMARKS |
|---|---|---|---|---|
| $\gamma$ | 4–4½ | 8″ | 359° | White, yellow. Disagreement as to colors. |
| $\lambda$ | 5–8 | 37″ | 45° | White, lilac. |
| 14 | 5½–9–7 | 93″ | 36° | White, blue, lilac. |
| Triple | | 106″ | 278° | |
| 30 | 6–7 | 38″ | 273° | Both white. A beautiful double. |
| 33 | 6–9 | 28″ | 0° | Topaz, sapphire. |
| $\pi$ | 5–8–11 | 3.24″ | 122° | |
| Triple | | 25″ | 110° | |
| 1 | 6–7 | 2.6″ | 170° | |

($\alpha$) is 40 light years distant, and has a proper motion of eight miles per second. It is a star of the solar type.

($\gamma$) was the first double discovered. It was discovered by Hooke in 1664, when he was following a comet.

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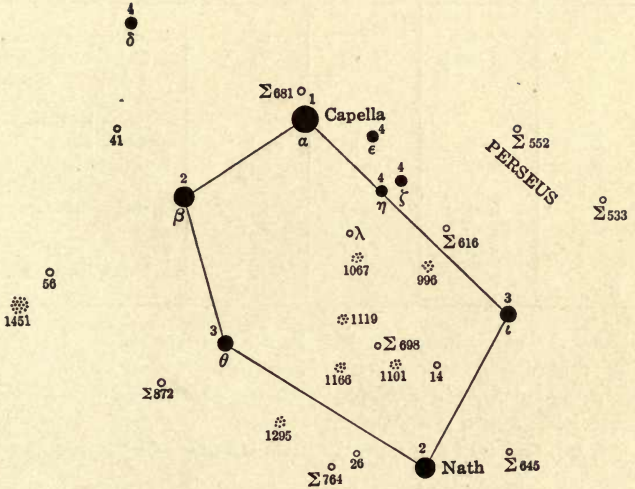
| DOUBLE STAR | MAGNITUDES | DISTANCE | ANGLE | REMARKS |
|---|---|---|---|---|
| Σ616 | 5–9 | 6″ | 350° | Greenish, white. |
| 26 | 5–8–11 | 12″ | 268° | Yellow, blue. |
| Triple | | 26″ | 113° | |
| 14 | 5–7½–11 | 14″ | 224° | Yellow, blue. |
| Triple | | 12″ | 342° | |
| λ | 5–9 | 121″ | 13° | |
| 41 | 5–6 | 8″ | 354° | White, violet. |
| Σ872 | 6–7 | 11″ | 217° | Yellow, lilac. |
| Σ645 | 6–8 | 12″ | 27° | White, ash. |
| Σ681 | 6½–9 | 23″ | 181° | |
| Σ698 | 6–7½ | 31″ | 346° | Yellow, bluish. Beautiful. |
| Σ764 | 6–7 | 25″ | 13° | |
| 56 | 5½–8 | 48″ | 21° | |
| Σ533 | 6–7½ | 20″ | 60° | In Perseus. |
| Σ552 | 6–6 | 9″ | 114° | In Perseus. |

Smythe describes the cluster 1119 as "an oblique cross, with a pair of large stars in each arm, and a conspicuous one in the centre, the whole followed by a bright star of the seventh magnitude." There are several wide doubles scattered through it and the whole region is very beautiful. Of the cluster 1295 Webb says, "Even in small instruments it is extremely beautiful. One of the finest of its class." Capella is probably 30 light years distant. Peters gives 70 light years, Struve 11. It has a proper motion of 11 miles per second, and is receding from the earth at the rate of 17 or 23 miles per second. It is a model star of the solar type.

The light of (ζ) is singularly intense for its magnitude.

# AURIGA

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## CAPRICORNUS

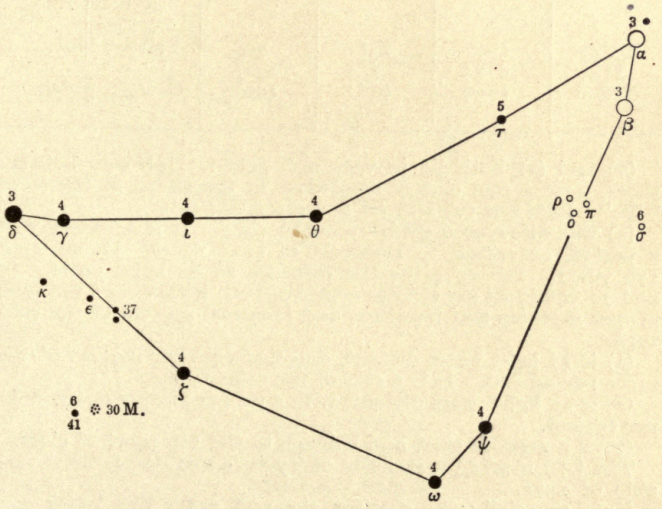
| DOUBLE STAR | MAGNITUDES | DISTANCE | ANGLE | REMARKS |
|---|---|---|---|---|
| $\alpha$ | 4–8½<br>3–10½ | 44″<br>7.4″ | 220°<br>150° | A naked eye double, and telescopic double double. Both yellow. |
| $\beta$ | 3–6 | 205″ | 267° | Gold, blue. |
| $o$ | 6–7 | 22″ | 240° | White, bluish. A pretty pair. |
| $\sigma$ | 6–9 | 54″ | 177° | Orange, blue. |
| $\pi$ | 5–9 | 3.4″ | 145° | |
| $\rho$ | 5–8 | 3.8″ | 177° | Yellow, purple. Fine contrast. |

Note the star cluster 30 M. It lies a little north of (41), a fifth magnitude star. Webb describes it as "moderately bright, beautifully contrasted with an eighth magnitude star beside it." Use a power of about 70.

($\pi$), ($\rho$), and ($o$) form a pretty little triangle of fifth magnitude stars.

In a good glass five stars should be seen in the field with ($\alpha$).

# CAPRICORNUS

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## CASSIOPEIA

| DOUBLE STAR | MAGNITUDES | DISTANCE | ANGLE | REMARKS |
|---|---|---|---|---|
| $\eta$ | 4–7½ | 5″ | 200° | White, purple. |
| $\sigma$ | 5–7 | 3″ | 324° | Green, blue. Coloring intense. |
| $\Psi$ | 4½–8½ | 30″ | 101° | |
| $\iota$ | 4–8 | 7″ | 112° | |
| $\alpha$ | 2–9 | 62″ | 280° | |
| $\Sigma$163 | 6–8 | 35″ | 33° | Gold, blue. Remarkable colors. |
| $\Sigma$3053 | 6–7 | 15″ | 70° | Yellow, blue. |
| $\Sigma$191 | 6–8½ | 5″ | 190° | |
| O$\Sigma\Sigma$26 | 6–6½ | 63″ | 199° | Orange, green. |

($\gamma$) and ($\kappa$) both lie in very rich fields. Half-way between them, note a fine cluster somewhat in the shape of the letter "W." Between ($\pi$) and ($o$) is a glorious field.

($\eta$) was discovered by Herschel in 1779. It is a binary with a period, according to Doberck, of 222½ years. Duner gives 176 years. Struve gives the distance as 22 light years. ($\eta$) and 70 Ophiuchi are similar systems, both have about the same proper motions and parallax, and identical spectra of the solar type.

($\alpha$) is 47 light years distant, and has a proper motion of two miles per second. It is a star of the solar type.

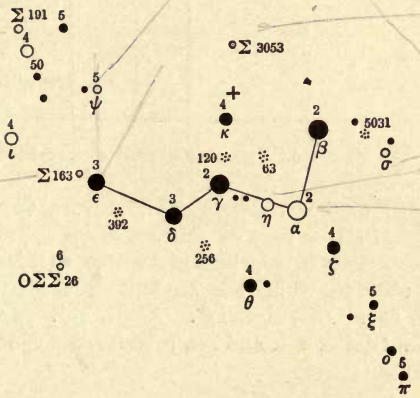
($\beta$) is 20 light years distant, with a proper motion of ten miles per second.

($\gamma$) is a gaseous star, and belongs to the 5th spectral class.

The (+) marks the position of Tycho's star, the famous variable of 1572.

Note especially the clusters 392 and 256. The latter contains a double, magnitudes 8–9.

# CASSIOPEIA





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Andromeda Page 41
Perseus Page 63
Pegasus Page 61

## CEPHEUS

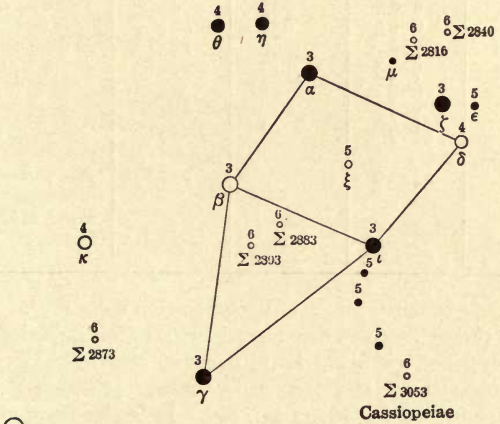
| DOUBLE STAR | MAGNITUDES | DISTANCE | ANGLE | REMARKS |
|---|---|---|---|---|
| $\beta$ | 3–8 | 13″ | 250° | White, blue. |
| $\delta$ | 4½–7 | 41″ | 192° | Yellow, blue. |
| $\xi$ | 4½–6½ | 6.8″ | 282° | Yellow, blue. |
| $\kappa$ | 4–8 | 7″ | 124° | White, blue. |
| Σ2816 | 6–8–8 | 12″ | 120° | |
| Triple | | 20″ | 339° | |
| Σ2893 | 5½–7½ | 28″ | 348° | Yellow, white. |
| Σ2840 | 6–7 | 20″ | 194° | Greenish white, bluish white. A splendid pair. |
| Σ2873 | 6–7 | 13″ | 77° | |
| Σ2883 | 6–8 | 15″ | 254° | White, blue. |

Note ($\mu$), the so-called "garnet star," the reddest star in the northern hemisphere.

Many small meteor showers radiate from Cepheus during the middle and latter part of June.

The double Σ3053 Cassiopeiæ is given here, as it is conveniently located to observe while the student is exploring Cepheus. Magnitudes, 6–7. Distance, 15″. Angle, 70°. Yellow, blue.

($\delta$) is a beautiful double and has been likened to the celebrated ($\beta$) Cygni.

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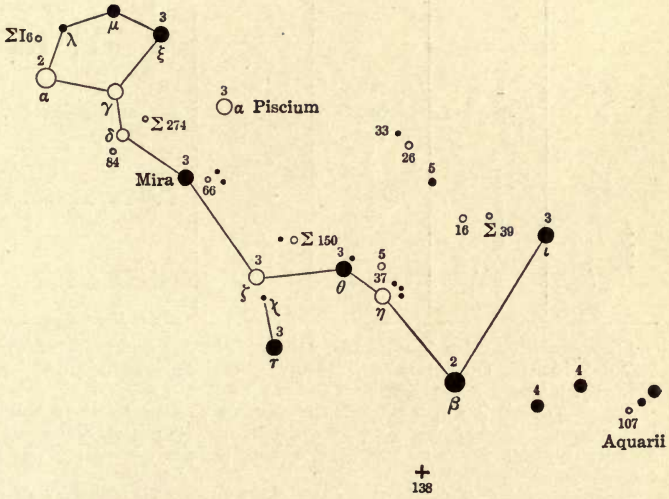
Cygnus Page 59
Draco Page 9
Ursa Minor Page 37

| DOUBLE STAR | MAGNITUDES | DISTANCE | ANGLE | REMARKS |
|---|---|---|---|---|
| 26 | 6–9 | 16″ | 252° | Topaz, lilac. |
| $\eta$ | $3\frac{1}{2}$–$9\frac{1}{2}$ | 225″ | 305° | |
| $\zeta$ | 3–9 | 185″ | 40° | |
| $\gamma$ | 3–7 | 3″ | 288° | Yellow, blue. A beautiful double. |
| 37 | 5–7 | 50″ | 331° | |
| 66 | 6–8 | 15″ | 228° | Yellow, blue. |
| $\Sigma$39 | 6–$8\frac{1}{2}$ | 20″ | 45° | Yellow, bluish. |
| 16 | 6–$8\frac{1}{2}$ | 65″ | 289° | |
| $\Sigma$150 | 7–8 | 36″ | 195° | A fine double. |
| $\Sigma$274 | 7–$7\frac{1}{2}$ | 13″ | 218° | |
| 84 | 6–9 | 4″ | 334° | |
| $\Sigma$I6 | 7–7 | 81″ | 162° | |
| 107 Aquarii | $5\frac{1}{2}$–7 | 6″ | 138° | Coloring fine. |
| $\alpha$ | $2\frac{1}{2}$–10 | | 258° | A wide double. Note a blue $5\frac{1}{2}$ Mg. star in the field. |

($\chi$) has a seventh magnitude companion distant 3′.

Note the nebula 138 discovered by Caroline Herschel in 1783. It is described as being long, narrow, and bright.

The famous variable Mira is in Cetus. It was first observed as a variable by Fabricius in 1596. It varies from the second to the ninth magnitude. Its period averages 331 days. Mira is a red star with banded spectra.

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Eridanus Page 73

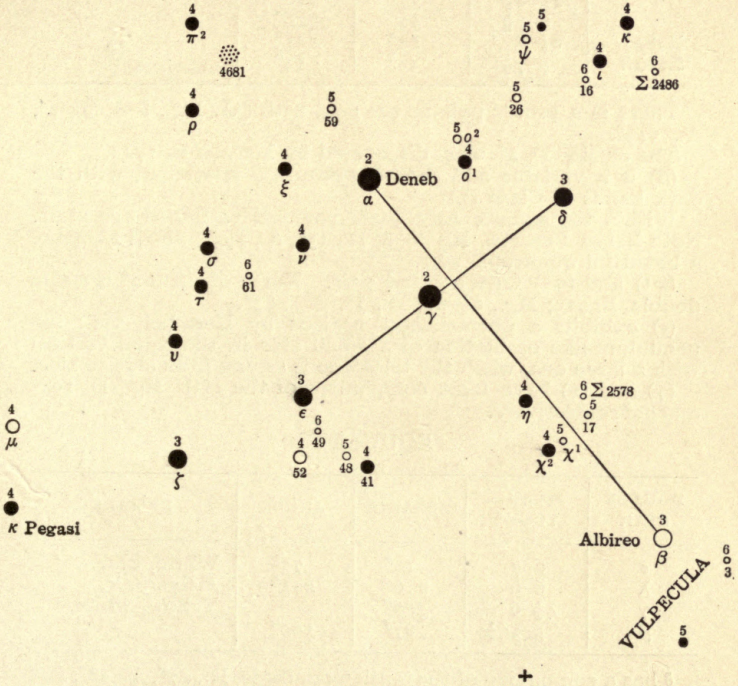
| DOUBLE STAR | MAGNITUDES | DISTANCE | ANGLE | REMARKS |
|---|---|---|---|---|
| $\beta$ | 3–7 | 34″ | 55° | Yellow, blue. Very fine. |
| 52 | 4–9 | 6″ | 60° | Yellow, blue. Good contrast. |
| 17 | 5–8 | 26″ | 73° | Red, blue. |
| $o^2$ | 4–7½ | 107″ | 174° | Orange, blue. |
| | 4–5½ | 358″ | 324° | Good contrast. A double double. |
| $\psi$ | 5½–7½ | 3″ | 184° | White, lilac. |
| 61 | 6–6 | 21″ | 122° | 6 light years distant. Nearest to earth in the northern hemisphere. |
| 59 | 5–9 | 20″ | 352° | |
| $\mu$ | 5–6–7½–12 | 2.4″ | 121° | A quadruple star. |
| | | 208″ | 56° | |
| | | 35″ | 264° | |
| 16 | 5½–5½ | 37″ | 136° | |
| 26 | 5–8½ | 41″ | 146° | Yellow, blue. |
| 48 | 6–6 | 178″ | 174° | |
| $\Sigma 2486$ | 6–6½ | 10″ | 224° | |
| $\Sigma 2578$ | 6½–7½ | 15″ | 127° | |
| $\chi^1$ | 5–9 | 26″ | 73° | In fine field. |
| 3 | 6–6 | 54″ | 5° | |

Observe with a low power the wonderful star stream about ($\gamma$). " + " locates the celebrated "Dumb-bell" nebula in Vulpecula (M. 27). Use a low power.

($\alpha$) or Deneb is approaching the earth at the rate of 36 miles per second. According to Newcomb it will eventually become so near a neighbor as to outshine during several thousand years every visible star.

Between ($\alpha$) and ($\epsilon$) is the dark rift in the Milky Way called the "coal sack."

330 separate photographs were taken of (61) in 1886–7. These furnished material for 30,000 measurements.

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Pegasus Page 61
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Cepheus Page 55

## PEGASUS

| DOUBLE STAR | MAGNITUDES | DISTANCE | ANGLE | REMARKS |
|---|---|---|---|---|
| $\epsilon$ | $2\frac{1}{2}$–8 | 138″ | 324° | Yellow, violet. Coloring fine. |
| 1 | $4\frac{1}{2}$–$8\frac{1}{2}$ | 37″ | 310° | |
| 3 | 6–$7\frac{1}{2}$ | 39″ | 349° | |
| $\Sigma$2841 | $6\frac{1}{2}$–8 | 22″ | 111° | |
| $\Sigma$2848 | 7–$7\frac{1}{2}$ | 10″ | 54° | |

There is a pretty pair in the field with (3); Mg., 8–8, D., 7″, A., 349°.

The cluster 15 M. was discovered by Maraldi in 1745.

($\beta$) is a variable and shows a beautiful spectrum, with the dark bands of Class III.

Within the square, Argelander counted 30 naked eye stars. Note $\Sigma$2894 Lacertæ, Mg., 6–8, D., 15″, A., 193°; also 8 Lacertæ, a beautiful quadruple star.

($\pi^1$) and ($\pi^2$) form a grand pair. North of them 2° is a fine double, $\Sigma$2905; Mg., $8\frac{1}{2}$–$8\frac{1}{2}$, D., 3″, A., 283°.

($\epsilon$) exhibits a phenomenon noticed by Herschel, viz.: the pendulum-like oscillation of a small star in the same vertical with a large one, when the telescope is swung from side to side.

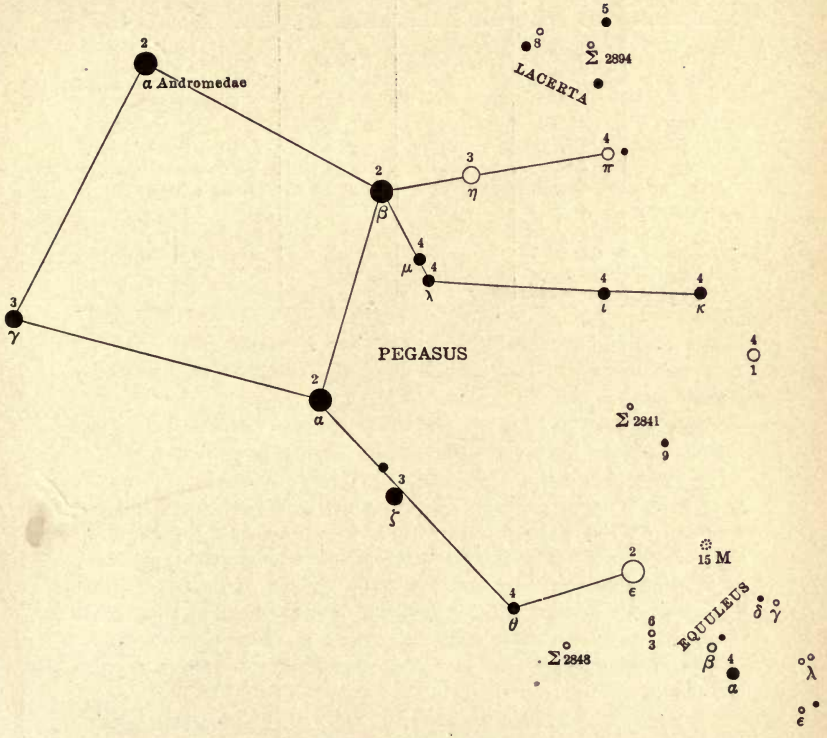
($\gamma$) and ($\eta$) have faint companions of the 11th Mg., D. 162″ and 90″ respectively.

## EQUULEUS

| DOUBLE STAR | MAGNITUDES | DISTANCE | ANGLE | REMARKS |
|---|---|---|---|---|
| $\epsilon$ | 6–7 | 11″ | 75° | White, blue. |
| $\lambda$ | 6–6 | 2.6″ | 225° | A fine pair. |
| $\gamma$ | $4\frac{1}{2}$–6 | 366″ | | Yellow, white. |
| $\beta$ | 5–$10\frac{1}{2}$ | 67″ | 309° | |

$\delta$ has a companion of the tenth magnitude, D., 27″, A., 38°, and is remarkable for the fact (I quote from Mrs. Martin's *Friendly Stars*) "that it is supposed to have a period of only 5 years, the shortest yet discovered for a visual binary."

## PEGASUS AND EQUULEUS





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Aquarius Page 43
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## PERSEUS

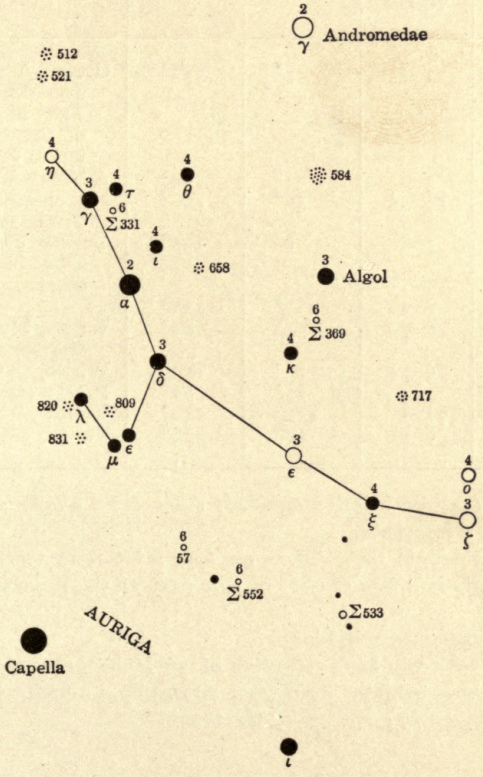
| DOUBLE STAR | MAGNITUDES | DISTANCE | ANGLE | REMARKS |
|---|---|---|---|---|
| $\eta$ | 4–8 | 28″ | 300° | White, blue. Several faint stars near it. |
| $\epsilon$ | 3–8 | 9″ | 9° | |
| $\zeta$ | 3–9 | 13″ | 207° | A quintuple star. |
| 57 | 5–6 | 114″ | 198° | Yellowish, lilac. |
| $\Sigma 552$ | 6–6½ | 9″ | 114° | Both white. |
| $\Sigma 331$ | 5–7 | 12″ | 85° | |
| $\Sigma 533$ | 6–7½ | 19″ | 60° | |
| $\Sigma 369$ | 6½–8 | 3·5″ | 28° | Yellow, blue. |
| o | 4½–9½ | 20″ | 237° | |

($\alpha$) is 44 light years distant, and has a proper motion of one mile per second. It is approaching the earth at the rate of 7 miles per second.

Algol is approaching the earth at the rate of two miles per second. It is a star of the Sirian type. The variability of Algol was doubtless discovered in very ancient times. Its period is 2 days, 20 hrs., 48 m. During 2 hrs., 14 m., Algol appears of the second magnitude, the remaining 6¾ hrs. are occupied by a gradual decline of the star to the fourth magnitude, and its equally gradual return to the second magnitude. The variability is caused by the periodic eclipse of Algol by a dark companion, whose distance from Algol is three million miles.

The clusters 512 and 521 are considered the finest in the heavens.

The cluster 584 has a diameter of 15′. Over 100 stars can be counted in it. Very fine low power field.

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Auriga Page 49
Cassiopeia Page 53

## PISCES

| DOUBLE STAR | MAGNITUDES | DISTANCE | ANGLE | REMARKS |
|---|---|---|---|---|
| $\alpha$ | 3–4 | 3″ | 320° | Green, blue. A fine double. The movement of the companion is very slow. |
| $\zeta$ | 5–6 | 24″ | 64° | A beautiful sight. |
| $\psi$ | $5\frac{1}{2}$–$5\frac{1}{2}$ | 30″ | 160° | No change noted in 130 years. |
| 55 | 5–8 | 6″ | 192° | Yellow, blue. Two beautiful stars. |
| 65 | 6–6 | 4.5″ | 118° | |
| 77 | 6–7 | 33″ | 82° | White, blue. No change noted. |
| 35 | 6–$7\frac{1}{2}$ | 11″ | 150° | White, purple. |
| 51 | 5–9 | 27″ | 82° | Pretty pair. |
| 38 | $7\frac{1}{2}$–8 | 4.5″ | 240° | Yellow, white. |
| 42 | 6–11 | 29″ | 338° | Topaz, emerald. |

($\rho$) and (94), both fifth magnitude stars, form a splendid pair.

($\kappa$) is in a fine field.

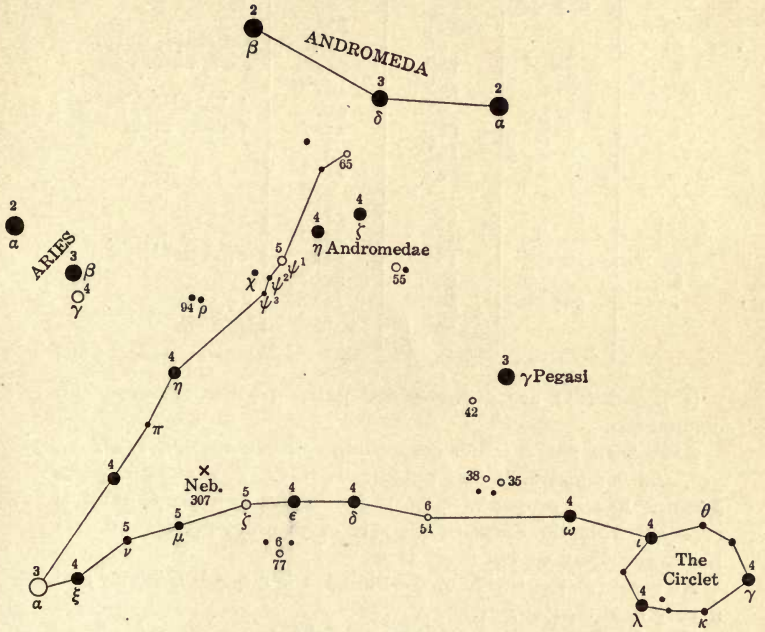
Note the nebula 307. There are four faint stars near it.

($\gamma$) Arietis is a fine double in this part of the heavens. See Aries.

($\xi$) is a spectroscopic binary.

Viewed with the Lick refractor of 36 inches, any given star is 32,400 times brighter than when shown by a 2-inch telescope.

($\nu$) is frequently occulted by the moon.

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## TAURUS

| DOUBLE STAR | MAGNITUDES | DISTANCE | ANGLE | REMARKS |
|---|---|---|---|---|
| Σ430 | 6–9–9½ | 26″ | 55° | |
| Triple | | 39″ | 302° | |
| 30 | 5–9 | 9″ | 58° | Emerald, purple. |
| $\phi$ | 6–8 | 56″ | 242° | Red, blue. |
| Σ674 | 6–9 | 10″ | 147° | |
| Σ716 | 6–7 | 5″ | 200° | A beautiful pair. |
| $\tau$ | 5–7 | 62″ | 212° | White, blue. |
| Σ548 | 6–8 | 14″ | 35° | |
| Σ495 | 6½–9 | 4″ | 216° | |
| $\chi$ | 6–8 | 19″ | 25° | |
| 111 | 5½–8 | 75″ | 271° | |
| Σ730 | 6½–7 | 10″ | 142° | |
| 62 | 6–8 | 28″ | 289° | Fine field. |
| 88 | 4–7½ | 69″ | 299° | |
| $o^2$ | 5–7–8 | 39″ | 304° | In Orion. |
| | | 54″ | 88° | Beautiful. |

($\theta^1$) and ($\theta^2$) are a naked eye pair. ($\sigma$) has a naked eye companion.

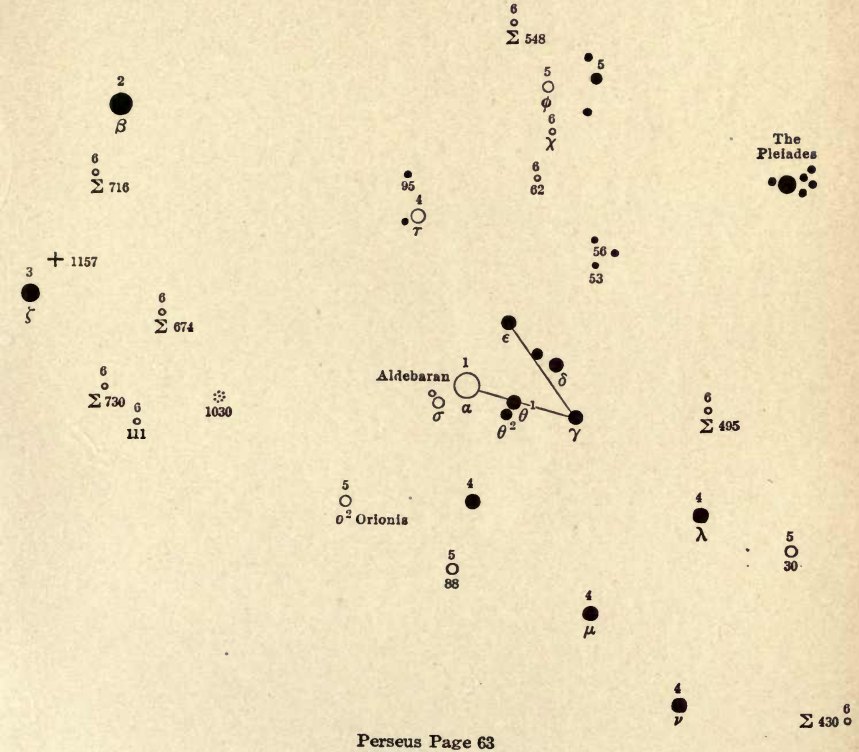
Aldebaran has a tenth magnitude companion, D., 114″, A., 35°, and is a standard first magnitude star. It is 28 light years distant, has a proper motion of four miles per second, and is receding from the earth at the rate of 30 miles per second. It has a spectrum of the solar type.

Alcyone ($\eta$), the lucida of the Pleiades, is a quadruple star and a very beautiful object.

The Pleiades are probably 250 light years distant. They have a common proper motion, and a spectrum of the Sirian type. A photographic plate of them shows over 2000 stars.

The (+) locates the celebrated "Crab Nebula," the first nebula discovered by Messier. Note the field about ($\zeta$).

# TAURUS





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# THE CONSTELLATIONS OF WINTER

## CANIS MAJOR

| DOUBLE STAR | MAGNITUDES | DISTANCE | ANGLE | REMARKS |
|---|---|---|---|---|
| $\mu$ | 5–8 | 2.8″ | 343° | White, blue. |
| $\nu^1$ | 5½–8 | 17″ | 262° | |
| H.3945 | 7–8 | 28″ | 67° | A fine pair. |
| $\epsilon$ | 2–9 | 7″ | 160° | |

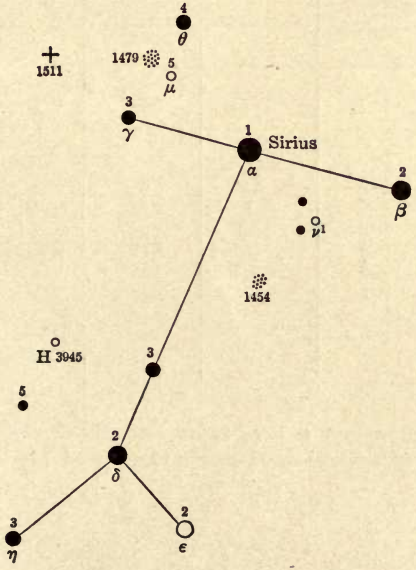
The cluster 1454 is a superb group visible to the naked eye. Look for a red star in its centre.

Sirius is a double, but too close for our telescope. It is eight light years distant, and has a proper motion of nine miles per second. According to Huggins it is receding from the earth at the rate of eighteen to twenty-two miles per second. Vogel raises this to forty-six miles. Sirius is the brightest representative of the great spectroscopic type 1, which includes more than half of all the stars yet studied. This brilliant sun is supposed to be surrounded by an enormous atmosphere of hydrogen. It is 63 times as bright as our sun.

Our sun would appear as a third magnitude star if as distant from the earth as is Sirius.

Note the nebula 1511 and the curving row of faint stars near it.

# CANIS MAJOR

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Lepus Page 77
Orion Page 81

## ERIDANUS

| DOUBLE STAR | MAGNITUDES | DISTANCE | ANGLE | REMARKS |
|---|---|---|---|---|
| 32 | 5–7 | 6.7″ | 348° | Topaz, bluish. Fine contrast. Discovered by Herschel, 1781. |
| 62 | 6–8 | 63″ | 73° | |
| Σ422 | 6–8 | 6″ | 232° | Gold, blue. |
| 39 | 6–9 | 6.4″ | 150° | |
| 55 | 7–7 | 10″ | 318° | Yellow, white. |
| Σ570 | 7–8 | 12″ | 258° | |
| Σ436 | 7–8 | 30″ | 232° | |
| γ | 2½–10 | 51″ | 238° | |
| $o^2$ | 4–10 | 82″ | 105° | Discovered by Herschel, 1783. |

Note the planetary nebula 826. Lalande described it as the most extraordinary object of the kind he had ever seen.

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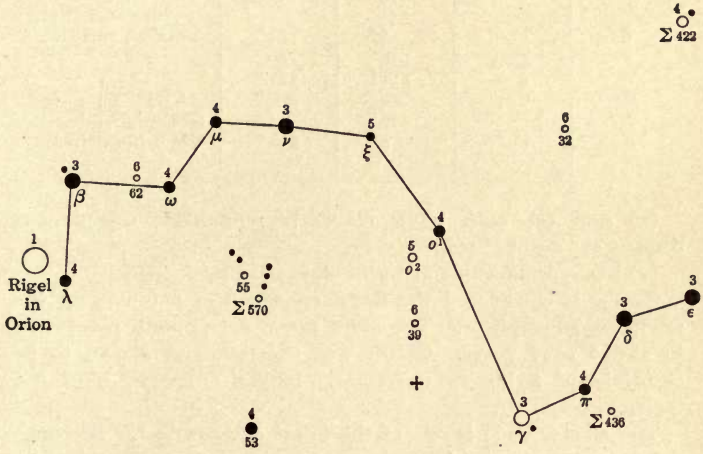
## ERIDANUS

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## GEMINI

| DOUBLE STAR | MAGNITUDES | DISTANCE | ANGLE | REMARKS |
|---|---|---|---|---|
| $\alpha$ | 2–3 | 6″ | 226° | Both yellow. A beautiful object. |
| $\zeta$ | 3–7 | 90″ | 355° | Yellow, blue. |
| 15 | 6–8 | 33″ | 205° | White, blue. |
| 38 | 6–8 | 6.5″ | 162° | Yellow, blue. Fine contrast. |
| $\delta$ | 3–8 | 7″ | 197° | Yellow, purple. |
| $\epsilon$ | 3–9 | 110″ | 94° | |
| $\nu$ | 4–8 | 112″ | 329° | |
| 20 | 6–7 | 20″ | 209° | |
| $\lambda$ | 3½–10 | 10″ | 31° | Greenish, blue. |
| $\kappa$ | 4–10 | 6″ | 231° | Very beautiful. |

($\pi$) and ($\mu$) both have eleventh magnitude companions distant 22″ and 73″ respectively.

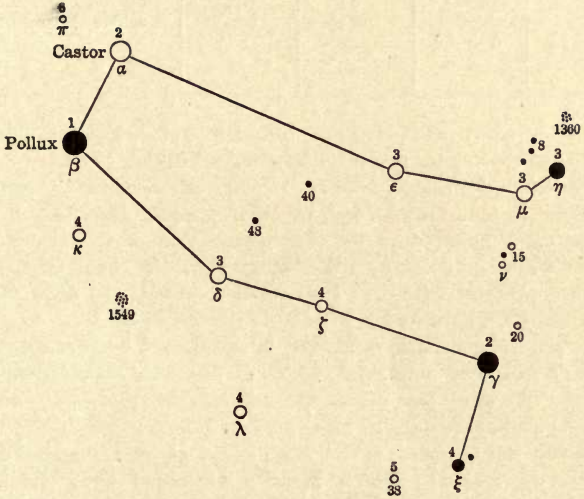
($\gamma$) has a remarkable array of stars near it.

Castor is considered the finest specimen of a binary in the northern hemisphere. The stars make a complete revolution in about 1000 years. Castor was the first star shown to be certainly of a binary character. It has a spectrum of the Sirian type.

The cluster 1360 is one of the finest clusters in the heavens. "A marvellously striking object. No one can see it for the first time without an exclamation."

Pollux is 48 light years distant, has a proper motion of 27 miles per second, and is approaching the earth at the rate of 33 miles per second. It is a coarse but fine triple star.

The region about ($\eta$) is very rich.





| | |
|---|---|
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| Taurus | Page 67 |
| Auriga | Page 49 |

## LEPUS

| DOUBLE STAR | MAGNITUDES | DISTANCE | ANGLE | REMARKS |
|---|---|---|---|---|
| α | 3–10 | 35″ | 156° | |
| γ | 4–8 | 94″ | 349° | Yellow, garnet. |
| κ | 5–8 | 2.5″ | 360° | Yellow, blue. |
| H. 3752 Triple | 6–9–8½ | 3.5″<br>59″ | 104° | |

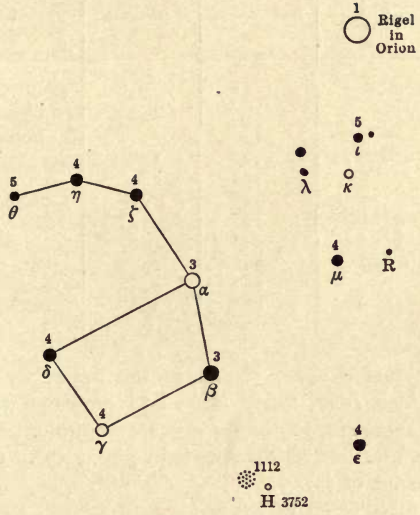
About 6′ from (α) is H. 3780, a multiple star, Mg. 7–8–9–8½, a beautiful cluster for small telescopes.

Note R., a celebrated variable, "Hind's crimson star." At its minimum it is intensely red in color. Hind describes it as resembling a blood drop on the background of the sky. As regards depth of color no other star visible in these latitudes can be compared with it. Its period is about 436 days. At maximum its magnitude is 6 to 7, at minimum 8.

"Its spectrum indicates that it is smothered with absorbing vapors, a sun near extinction, which at intervals experiences an accession of energy and bursts through its stifling envelope with explosive radiance, only to faint and sink once more."

Observe the cluster 1112, "A splendid globular cluster discovered by Mechain which Messier described as a starless nebula with a brilliant centre. Herschel was the first to resolve this nebula into stars. It appears from photographs taken that five stars out of the two hundred of this cluster are variable."

# LEPUS





Orion Page 81
Canis Major Page 71
Eridanus Page 73

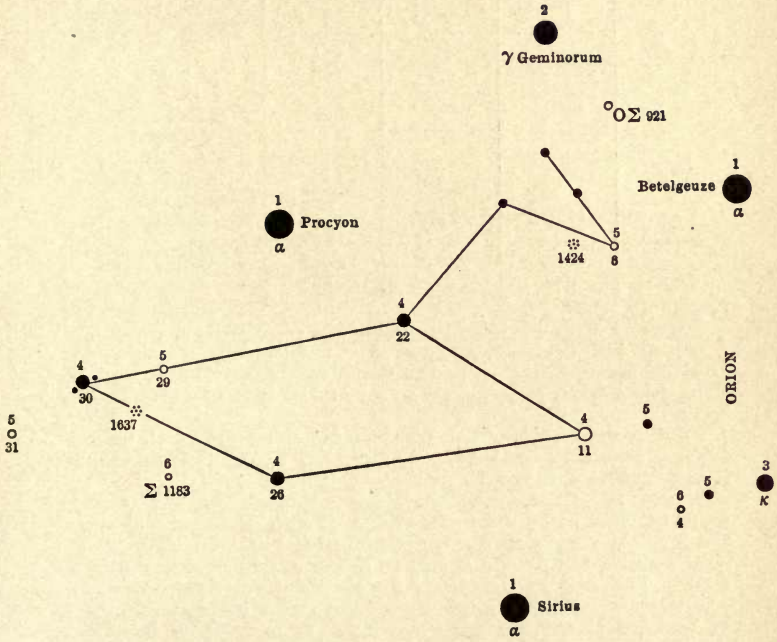
## MONOCEROS

| DOUBLE STAR | MAGNITUDES | DISTANCE | ANGLE | REMARKS |
|---|---|---|---|---|
| 11 | 5–6–7 | 7″ | 131° | One of the finest sights of the heavens. |
| Triple | | 9″ | 124° | |
| 4 | 6–10–11 | 3.4″ | 178° | |
| Triple | | 10″ | 244° | |
| 8 | 5–7 | 14″ | 24° | Golden, blue. |
| Σ921 | 6½–8 | 16″ | 4° | |
| Σ1183 | 5½–8 | 31″ | 326° | |
| 29 | 6–9½–9 | 31″ | 105° | |
| Triple | | 67″ | 245° | |
| 31 | 5½–8 | 78″ | 308° | Yellow, blue. |

Note the cluster 1424, visible to the naked eye, and very beautiful. Also 1637, fairly large and crowded with stars of the ninth magnitude, including a pretty double.

There is a glorious low power field about (8). Observe the fine orange color of (5).

(11) was discovered in 1781.

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Gemini Page 75

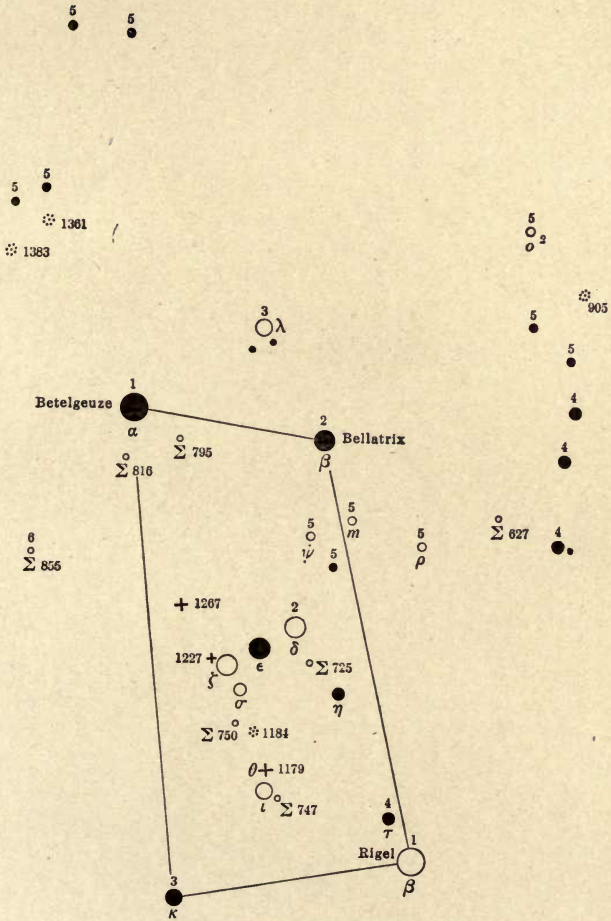
| DOUBLE STAR | MAGNITUDES | DISTANCE | ANGLE | REMARKS |
|---|---|---|---|---|
| $\delta$ | 2–7 | 53″ | 360° | White, blue. |
| $\iota$ | 3–7 | 11″ | 142° | Fine field. |
| $\lambda$ | $3\frac{1}{2}$–6 | 4″ | 43° | Yellow, red. Whole region fine. |
| $\rho$ | 5–$8\frac{1}{2}$ | 7″ | 62° | Yellow, blue. |
| $\zeta$ | 2–6–10 | 2.5″ | 149° | Yellow, blue. |
| Triple | | 56″ | 8° | |
| $\Sigma$747 | $5\frac{1}{2}$–$6\frac{1}{2}$ | 36″ | 223° | |
| $\Sigma$816 | $6\frac{1}{2}$–$8\frac{1}{2}$ | 4″ | 289° | |
| $\Sigma$627 | $6\frac{1}{2}$–7 | 21″ | 260° | A splendid pair. |
| m (23) | 5–7 | 31″ | 284° | Green, white. Fine coloring. |
| $\Sigma$855 | 6–7 | 29″ | 113° | A third star in field. |
| $o^2$ | 5–7–8 | 39″ | 204° | A beautiful object. |
| Triple | | 54″ | 88° | |
| $\Sigma$795 | 6–6 | 1.7″ | 200° | Excellent test. |
| $\Sigma$750 | 6–8 | 4″ | 59° | |

$\Sigma$725 and $\Psi$ have eleventh magnitude companions.

($\sigma$) is a beautiful multiple star, and is a colored variable. ($\epsilon$) and ($\beta$) are receding from the earth at the rate of 35 and 39 miles per second respectively; ($\alpha$) at the rate of 28 miles per second.

Proctor says a three-inch glass should show the ninth magnitude companion to Rigel. D., 9″, A., 199°. Smyth claims it is a test for a four-inch glass.

Words fail to describe the great nebula 1179. Its glories must be seen to be appreciated. A three-inch glass will show the four stars forming the trapezium in the nebula. The whole region about the nebula is rich in doubles, triples, and multiple stars. The nebula has been under effective observation for 244 years. It is the most conspicuous and interesting object of its kind in the northern heavens. It is receding from the earth at the rate of 11 miles per second, which is about the sun's computed velocity through space in the opposite direction. Hence the nebula is probably at rest.

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# THE MOON

## THE DIAGRAMS OF THE MOON

THESE are sketches from a series of fine photographs that recently appeared in Mr. Garrett P. Serviss's excellent book entitled *The Moon*. They are only intended to guide the student in the identification of the lunar wonders visible in a three-inch telescope, and make no claim to exactness or pictorial resemblance.

The mean distance of the moon from the earth is 238,818 miles. Its diameter is 2163 miles, and it is a little larger than the continent of South America. Because of the moon's comparative proximity to the earth, it is the easiest and most interesting of telescopic objects, especially to the owner of a small telescope.

A telescope which magnifies only one hundred times will show a spot on the moon's surface whose diameter is 1223 yards. One which magnifies a thousand times will enable us to perceive objects on her surface whose dimensions are only 122 yards, which does not much exceed the size of the Capitol at Washington. The highest power yet applied to the moon, a power of six thousand, brings her to an apparent distance of forty miles.

No object that could with the slightest appearance of

probability be ascribed to the labors of intelligent creatures has ever been detected on the moon's surface.

We know more of the physical formation of the face of the moon turned toward us, than we know of certain parts of Asia, South America, and the interior of Africa.

More than five hundred features of the lunar surface have received names. Water cannot possibly exist as a liquid on the moon, for the temperature of the moon's surface during the long lunar night is probably not far from 460 degrees below the zero mark on a Fahrenheit thermometer.

The light of the full moon, which equals the light of 100,000 stars of zero magnitude, is one-618,000th part of the sun's light, and about twelve times the light of the half moon. The moon reflects about one-tenth of the light which falls on it from the sun. In the whole heavens the stars give about one-eightieth as much light as the full moon. The earth reflects to the moon about fourteen times as much light as the moon sends to the earth.

It is best to observe the moon with a low power, and under the varying conditions of sunrise and sunset, "which, like the corresponding times of the earth, abound with grand and beautiful effects of light and shade."

The best view of an object on the moon's surface is to be had when it is on the terminator, as the boundary line between the illuminated and the unilluminated portions of the moon is called. Those objects which are on the

terminator early during the first quarter, will be found there early on the third quarter.

The occultation of a star by the moon is an interesting sight, and one that can be well observed by the owner of a small telescope. All occultations of importance are predicted in the nautical almanac. The instantaneous disappearance and reappearance of the star occulted is the striking feature of this event. The nautical almanac should be in the hands of every amateur astronomer. It is published several years in advance, and can be obtained of the Superintendent of Documents in Washington at small cost.

A partial list of occultations which occur at favorable times for observation, up to January 1, 1911, will be found on page 106.

Although the general statement is true that we see only half of the moon, to speak more correctly we see about fifty-nine per cent. of the moon's surface, although we never see this amount at any one time. This fact is due to the "balancings" or libration of the moon, as it is called. The student is advised to consult an astronomy for a further discussion of this subject, as the treatment of technical matters does not come within the scope of this book.

Because of the phenomena of libration, it is impossible to give a fixed position to the various formations on the moon's surface with respect to the moon's age, so that no precise instructions can be given where to look for them.

The nomenclature of the moon is interesting because it serves to immortalize the names of many of the wise men of old whose memory would otherwise sink into oblivion. The astronomer Riccioli of Bologna, who published a chart of the moon in 1650, is responsible for most of the names of the interesting features of the moon's surface, and many of them are fanciful beyond reason.

The fact that seems to impress most persons who view the moon for the first time through a telescope is the rapidity with which it passes out of the field of vision. The high magnification emphasizes the earth's motion to such an extent and the speed with which we are travelling is thus made manifest in such a startling way, that few gaze without expressing their astonishment. Then, too, the detail brought out by even a low power is a matter of wonder. It seems almost incredible that in a small telescope craters on the moon only six miles in diameter can be seen distinctly.

Only a portion of what appears on the earlier diagrams is repeated in the successive views, as their repetition would tend to fill up the diagram with names leading to confusion. In each diagram therefore, particular stress is laid on the additional features of the moon's surface that the ever-advancing sunlight reveals.

The word crater is used in connection with the great ringed depressions, surrounded by mountains, that are so numerous on the moon's surface. It is a misnomer as applied to these formations which are totally unlike ter-

restrial craters. No doubt they are of volcanic origin, but here the analogy ceases. Nothing on the earth is like them. Ringed plains is perhaps the best name for them, as it is descriptive in a measure. They are like great amphitheatres, sometimes 100 miles in diameter, surrounded by gigantic mountain walls that rise almost abruptly thousands of feet high. They often contain a central mountain, or a bowl-like pit.

The lunar landscape is all on a stupendous scale. It is said that there are twenty-eight peaks on the moon that exceed in height our most lofty mountains. Everywhere on the moon's surface are traces of cataclysmic action that is almost beyond our comprehension.

In conclusion, the diagrams of the moon represent its telescopic or inverted appearance, so that the north point is at the bottom, the south at the top, the east to the right, the west to the left side of the diagrams respectively.

## MOON—PLATE I

The narrow crescent of the moon illumined by the sun, as shown in the opposite plate, presents few objects of interest to the observer, but as each successive night of observation until the moon is full presents new material worthy of attention, it is well for the student to master the details as they are presented.

The Mare Crisium, or the Sea of Crises or Conflicts, as it is called, is the most prominent object visible at this time, and because of its dark hue the analogy to a sea is striking. It measures 350 miles from north to south, 280 miles from east to west. Note Cape Agarum, 11,000 ft. high, jutting out into the sea on the southwest, and two small craters on the surface of the sea's floor a little east of its centre. The southern one is named Picard, the northern Pierce.

North of the Mare Crisium is the crater Cleomedes. It is 80 miles in diameter. One peak on its wall is 10,000 feet high and it contains a central mountain divided by three clefts. On its eastern wall is a very deep crater named Tralles.

If the atmospheric conditions are favorable, a certain amount of detail can be seen on the dark or earthlit portion of the moon. The brilliant crater Aristarchus, and the darkest crater, Grimaldi, on the eastern limb of the moon, have been seen.

PLATE I

Moon's Age 3.85 Days

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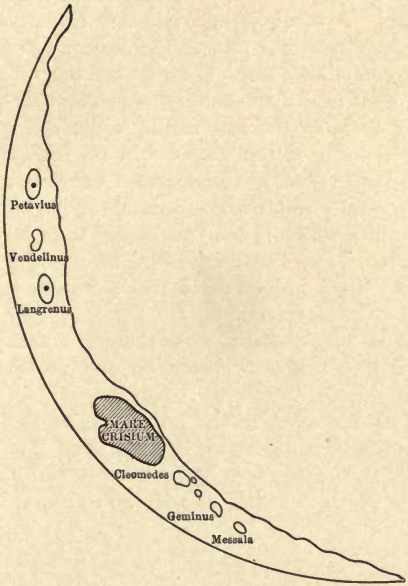


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## MOON—PLATE II

Petavius is one of the finest objects on the moon. It measures 100 miles from north to south. Its wall is divided by many valleys, while in the centre of its vast plain rises a mountain 5600 feet high. A straight line radiates from this mountain, extending southeast to the wall of the crater. This line, which in reality is a great cleft, one of many on the moon's surface, can be easily seen in a three-inch glass. The best time to view it is a day or so after the full moon, when the sun is setting on the western limb of the moon. In formation these clefts or rills, as they are called, are analogous to our western canyons. Petavius is especially noteworthy because of the convexity of its floor, the centre of which is 800 feet higher than its edges.

Langrenus is 90 miles in diameter. It contains a mountain peak 5800 feet high. Note three small craters just northeast of Langrenus forming a triangle.

Vendelinus is pear-shaped, and therefore easily identified. Note a small but brilliant crater on the northeastern slope of Furnerius.

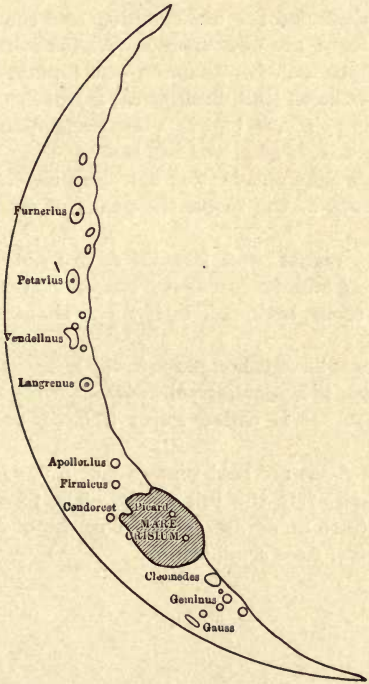
Burckhardt is the name of the crater just north of Cleomedes. North of it is Geminus, 54 miles in diameter. Its western wall rises to a height of 16,700 feet.

Gauss, from north to south, measures 110 miles.

PLATE II

**Moon's Age 3.87 Days**

S

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## MOON—PLATE III

The diamond-shaped Sea of Fecundity and the Sea of Nectar, pentagonal in form, are now visible. At the south of the latter sea, note Frascatorius with its north wall broken down. Endymion near the western limb is elliptical in appearance. Its west wall in places is 15,000 ft. high. View Endymion 3 d. 7 h. after the new, and 2 d. 9 h. after the full moon.

N. W. of Fabricius and Metius is a deep cleft. On the tip of the southern horn of the moon the peaks of the Leibnitz Mts. may be seen.

Messier, 9 m. across, and Messier A are noteworthy. Two slightly diverging streaks run east from the latter for a long distance. They seem artificial, but their character is still an enigma.

Alleged changes have taken place in the shape of these craters.

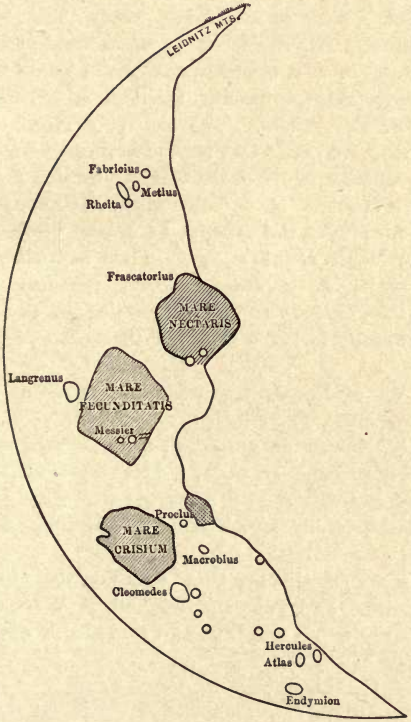
East of Proclus is a peculiar yellowish-brown patch somewhat diamond-shaped. It is called Palus Somnii, or "Marsh of a Dream."

Hercules and Atlas are best viewed 5 or 6 days after the new moon, or 3½ days after the full moon. The former contains a crater pit, and is 46 m. across. In the centre of Atlas, which is 55 m. in diameter, rises a mountain.

## PLATE III

**Moon's Age 5.54 Days**

S

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## MOON—PLATE IV

Note the crooked line of the Altai Mts. and the Taurus and Hæmus ranges, with Pliny 32 m. across, between them. Dawes lies just west of Pliny.

East of the Sea of Nectar is a striking group, Theophilus, Cyrillus, and Catharina. The former is 64 m. across. Its wall in places is 18,000 ft. high. Its central peak can be seen beyond the terminator 5 d. after the new moon. Cyrillus is trapezoidal in form and contains two peaks. The N. W. portion of its wall has been demolished to make way for the wall of Theophilus.

Posidonius on the western shore of the Sea of Serenity is 62 m. across and contains a crater. Its interior plain lies about 2000 ft. below the outer surface of the moon. It is best viewed 6 d. after the new moon. North of it is a "V" shaped bay called the Lacus Somniorum or "Lake of Sleepers." A peculiar ridge winds its way from Posidonius to Pliny across the Sea of Serenity. South of Posidonius is Le Monnier with its eastern wall broken down.

Mt. Argæus, N. W. of Pliny, 8400 ft. high, is a fine sight when the moon is 5 d. old.

North of the Sea of Nectar note Isidore and Capella with a peak over 13,000 ft. high between them. The ring of Capella is cut down by a broad cleft.

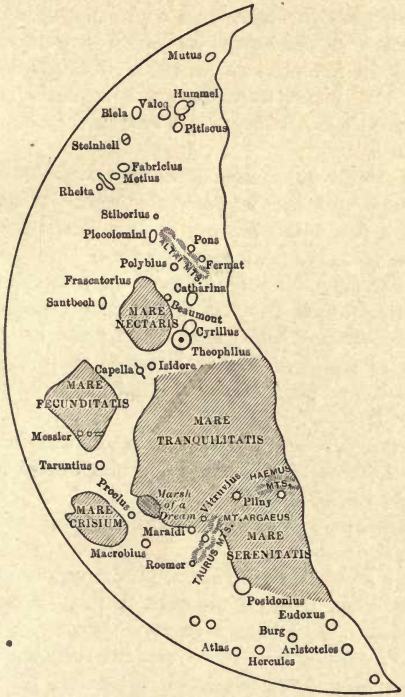
N. E. of the Mare Crisium note Vitruvius, Maraldi, Littrow and Rœmer.

South of Fabricius and Metius are three small craters close together, Pitiscus, Hommel, and Valcq. Steinheil, N. W. of them, is shaped like the figure "8". Polybius and Pons lie on opposite sides of the Altai Mts.

## PLATE IV

### Moon's Age 5.74 Days

S

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In the south Maurolycus, 150 m. across, and Stöfler are conspicuous. The former is best viewed about the time of the moon's first quarter. At full moon it is practically invisible. Some of its peaks are 15,000 ft. high.

About the centre of the moon, just west of the terminator, lie Albategnius, 65 m. across, and north of it Hipparchus, 90 m. in diameter. The latter exhibits signs of demolition and is presumably older than Albategnius which is very deep and comparatively perfect.

Note Menelaus and Sulpicius Gallus on the south shore of the Sea of Serenity, with Manilius between them. It is not known why these and a few other craters are so conspicuously bright.

The Caucasus Mts. are prominent south of Eudoxus and Aristoteles (50 m. across). In the centre of the range is Calippus.

The dotted line across the Sea of Serenity represents a light streak radiating from Tycho, 2000 m. to the southward. It crosses Bessel, 14 m. in diameter, situated in the midst of the Sea of Serenity. The character of the light streaks on the moon is unknown.

The small triangular shaped crater east of the Caucasus Mts. is Theætetus, interesting because a French observer claims to have seen smoke rising near it.

The Sea of Serenity is 430 m. long and about as wide. Its area is 125,000 sq. m.

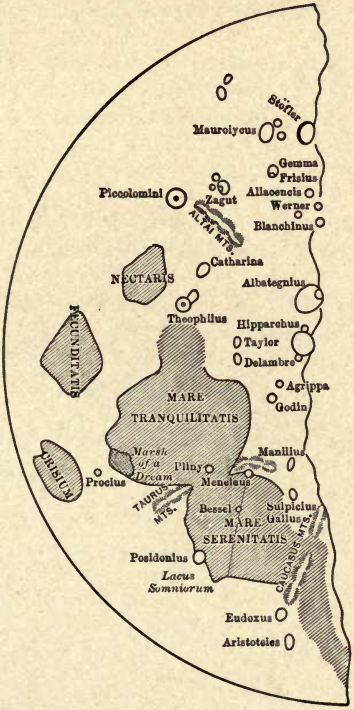
Godin, 23 m., and Agrippa, 27 m. in diameter, respectively, are fine objects when seen on the terminator. A minute point of light is alleged to have been seen near them.

S. E. of Piccolomini are three craters forming a triangle. Zagut is the name of the largest.

## PLATE V

**Moon's Age 7.75 Days**

S

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## MOON—PLATE VI

Clavius is conspicuous in the south. It is 140 m. across, 16,000 sq. m. in area, and a peak on its western wall is 17,300 ft. high. Within its walls 90 craters have been counted. If its surrounding wall were straight, it would cover the distance from New York to Buffalo.

Tycho, 54 m. in diameter, is the perfectly formed crater north of Clavius. A system of light streaks extending over a quarter of the visible hemisphere of the moon radiate from it.

North of Tycho, just west of the terminator, lie two groups containing three craters each. The largest in each group lies to the north.

The Apennine Mts., a grand range, start from Mt. Hadley, 15,000 ft. high, and terminate at Eratosthenes 450 m. to the S. E.

Eratosthenes, 38 m. across, is 8000 ft. deep. It contains three conspicuous central peaks.

Archimedes, 50, Autolycus, 23, and Aristillus, 34 m. in diameter respectively, lie north of the Apennines. Cassini, to the north of them, contains two central pits. More than fifty objects have been detected within the walls of Archimedes.

Note the small peak Linné north of Mt. Hadley. Alleged changes have been noted in its form.

The Alps are pierced by a great cleft 80 m. long and from $3\frac{1}{2}$ to $6\frac{1}{2}$ m. in width. Its depth is at least 11,500 ft.

Ariadæus is connected with Hyginus by a valley best observed at first quarter. Hyginus is situated on the western shore of the Mare Vaporum or "Sea of Mists."

Note the Sinus Æstuum, or "Gulf of Heats," south of the Mare Vaporum.

PLATE VI

Moon's Age 9.22 Days

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## MOON—PLATE VII

Note Cichus, north of Tycho. A crater on its eastern wall only 6 m. across can be seen.

West of Birt note the Lunar Railway or Straight Wall, a cliff line 65 m. long and 1000 ft. high, best viewed one or two days after the first quarter. The western shore of the Mare Nubium, or "Sea of Clouds," outlines the profile of the "old lady in the moon." Her hooked nose is just S. E. of Ptolemy. Note Bulliadus 38 m. across, and 9000 ft. deep, and Gassendi, 55 m. in diameter. There are many curious clefts in the wall of Gassendi. North of it is Letronne, its north wall broken down.

Copernicus is conspicuous. It contains 8 central peaks, 3 of which are bright ones, and one is 2400 ft. high.

Plato, 60 m. across, is one of the darkest spots on the moon. Hevelius called it "the great black lake." South of it note Pico 8000 ft. high.

Capes Heraclides and La Place are at the eastern and western extremities respectively of the Sinus Iridum or "Bay of Rainbows." They are 135 m. apart. The former is 4000 ft. high, and its shadow forms the silhouette of the "moon maiden," best viewed when the moon is 11 days old.

The Carpathian Mts. north of Copernicus are best viewed 10 days after the new moon. East of them is Tobias Mayer, 20 m. across and 9700 ft. deep. Kepler, 22 m. across, is notably bright.

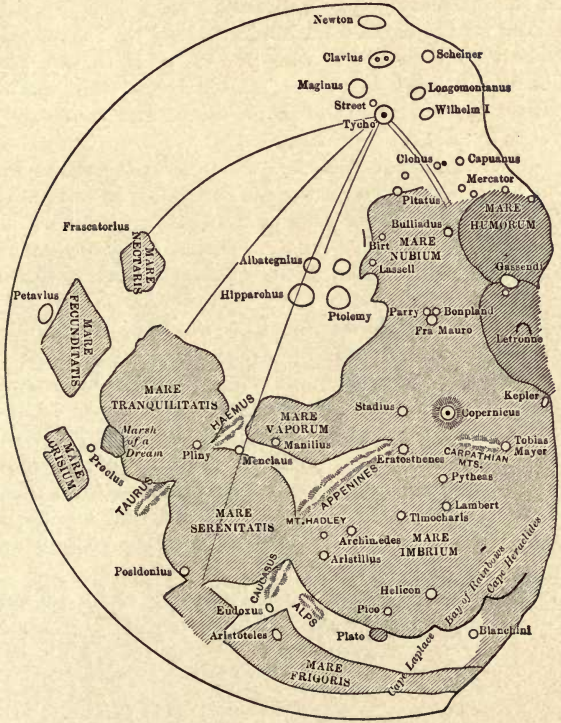
Newton, south of Clavius, is 142 m. long and 24,000 ft. deep, the deepest crater on the moon.

Note the circular Mare Humorum or "Sea of Humors," the darkest of the seas.

## PLATE VII

### Moon's Age 11.78 Days

S

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## MOON—PLATE VIII

The telescopic view of the full moon, contrary to the popular notion, is disappointing. The brilliancy of the reflected light dazzles the eye, eliminates the shadows of the great peaks, and renders the interesting details invisible.

Grimaldi on the eastern limb, 148 m. long by 129 m. broad, is the darkest spot on the moon. N. W. of it in the Oceanus Procellarum or "Ocean of Tempests" is Aristarchus, the brightest spot on the moon. It is 28 m. across and connected with Herodotus by a short bright ray.

Herodotus is 24 m. across. A winding valley starts from it and can be traced across the sea for a distance of 100 m.

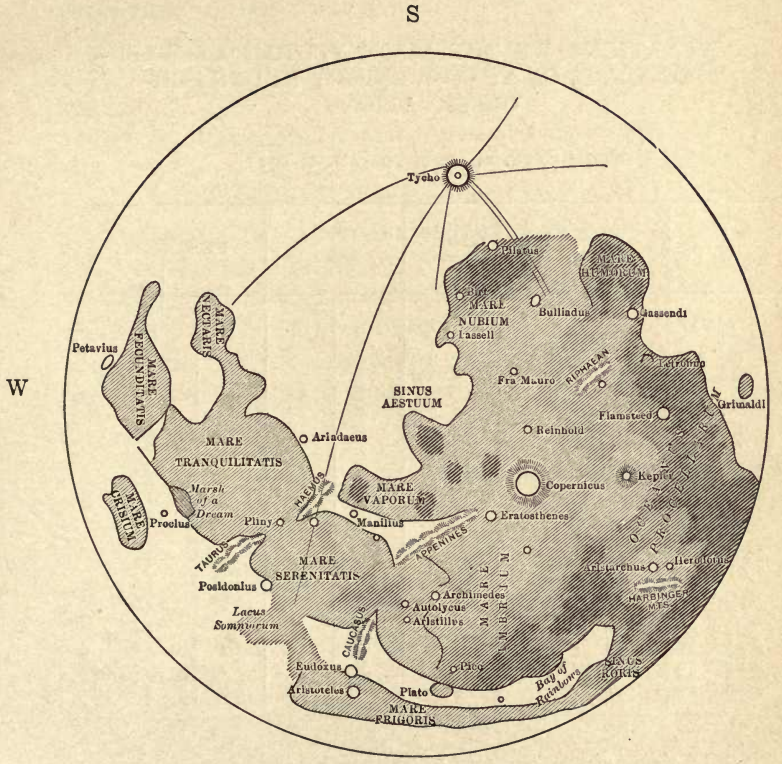
Note the dark patches west of Copernicus, the color of the Palus Somnii, the brilliant craters Proclus, Ariadæus, Menelaus, Manilius, Sulpicius Gallus, Pico, Aristarchus, and the black craters Plato and Grimaldi.

Observe the Riphæan Mts. north of the Mare Humorum, and the Harbinger Mts. north of Aristarchus. The dark patch north of the Mare Imbrium, extending from the Caucasus Mts. to the Oceanus Procellarum, is the Mare Frigoris, or "Sea of Cold." The bay that seems to connect the Mare Frigoris with the Oceanus Procellarum, north of the Bay of Rainbows, is the Sinus Roris, or "Gulf of Dews." Archimedes, Autolycus, and Aristillus are surrounded by an area of a lighter hue than that of the Mare Imbrium. This region is called "The Marsh of Corruption."

All the southern and western portions of the moon are wanting in detail, owing to the intensity of the light.

## PLATE VIII

### Moon's Age 14.40 Days



## OCCULTATIONS BY THE MOON VISIBLE AT WASHINGTON, D. C., AT CONVENIENT HOURS FOR OBSERVATION

FROM SEPT. 1, 1909, TO JAN. 1, 1911

| DATE | STAR OR PLANET | MAGNITUDE | DISAPPEARANCE | | DURATION | |
|---|---|---|---|---|---|---|
| | | | h. | m. | h. | m. |
| 1909 | | | | | | |
| Sept. 1 | Mars | | 8 | 42 | | 57 |
| " 3 | $\xi$ Arietis | 5.5 | 9 | 28 | | 8 |
| " 29 | 26 Ceti | 6 | 7 | 41 | | 59 |
| Oct. 20 | $\sigma$ Sagittarii | 2.3 | 7 | 1 | | 59 |
| " 24 | 69 Aquarii | 5.6 | 8 | 8 | 1 | 17 |
| " 24 | $\tau$ Aquarii | 4.4 | 9 | 41 | 1 | 6 |
| Nov. 19 | 37 Capricorni | 5.7 | 8 | 36 | | 59 |
| " 23 | 33 Ceti | 6.1 | 8 | 58 | 1 | 14 |
| Dec. 22 | 31 Arietis | 5.7 | 7 | 18 | | 46 |
| 1910 | | | | | | |
| Jan. 20 | 53 Tauri | 5.3 | 10 | 31 | 1 | 14 |
| " 26 | $\eta$ Leonis | 3.6 | 9 | 29 | 1 | 12 |
| Feb. 19 | 40 Geminorum | 6.3 | 8 | 7 | | 48 |
| Mar. 16 | $\tau$ Tauri | 4.5 | 7 | 26 | 1 | 14 |
| Apr. 12 | 56 Tauri | 5.2 | 7 | 12 | 1 | 1 |
| Aug. 10 | m Virginis | 5.4 | 8 | 35 | 1 | 1 |
| Nov. 17 | 95 Tauri | 6.2 | 9 | 59 | | 30 |

The time given for the occultations is the mean time at Washington, D. C. It is necessary for observers

elsewhere to correct the time to suit their respective locations. The longitude of Washington is west of Greenwich 5 hours 8 minutes 15.78 seconds.

The list given is only a partial one, and the student should consult the nautical almanac for the complete list.

The most beautiful occultations are those when the star disappears behind the dark limb of the moon as between new moon and first quarter.

Because of the moon's eastward motion relatively to the stars, the disappearances when viewed with the naked eye will take place on the eastern or left-hand limb of the moon, the reappearances on the western or right-hand limb. The reverse is true when the occultation is viewed through a telescope.

# THE PLANETS

# THE PLANETS

IN addition to the multitude of interesting objects connected with the universe of stars, there are the planets of our own system to be observed, and because their comparative proximity renders them more satisfactory objects to view in a small telescope, they are of greater interest to the amateur astronomer than those great suns that send us at best but faint messages of light, and concerning which our knowledge must for obvious reasons be largely conjectural.

The amateur astronomer with his three-inch glass has in the observation of the planets a source of pleasure that can never wane. Their numerous changes in position add variety to the observations, and their near approaches to the earth lend the zest of anticipation to the interested student.

There is the greatest satisfaction in seeing with your own eyes the peculiar characteristics of the planets that our own sun illumines, of which volumes have been written and which the whole race of intelligent beings have wondered at. Much more can be seen with a small telescope than is imagined, and the sight of the satellites of Jupiter and the rings of Saturn is far more impressive

and satisfactory than any amount of reading concerning them.

As this book is properly a hand-book, or a ready reference for the use of the observer, it is only necessary to call attention briefly to what can be observed of the planets with the optical power at our command. Taking up the planets in order, counting from the sun outward, the planet Mercury first claims our attention.

### MERCURY

So few have ever seen Mercury that even the very sight of that planet in an opera-glass is a source of satisfaction. The fact that it never reaches in its orbit a distance of more than 28 degrees from the sun, and that it is never visible for more than two hours after sunset or before sunrise, according as it follows or precedes the sun, accounts for the fact that it is so seldom seen.

The best time for searching for it is when it is farthest east or west of the sun, a fact which any good almanac will furnish. An opera-glass, because of its large field, is most useful in looking for Mercury, although if once glimpsed with the naked eye the telescope readily picks it up. In appearance it is brighter than a first magnitude star, and sometimes it seems of a reddish hue.

The transits of Mercury across the sun's disk average thirteen in every hundred years, and are exceedingly interesting events to watch even with a small telescope. The transits always occur in the months of May or

November. November, 1907, was the date of the last transit, and the next four will occur November 6, 1914; May 7, 1924; November 8, 1927; and May 10, 1937.

Aside from the satisfaction of seeing Mercury, a pleasure that was denied to Copernicus even, there is little to interest the amateur astronomer save to note the phases that the planet assumes, which are similar to those of the moon. The crescent Mercury gleaming in the waning light of the dying day, and seen for the first time is a sight never to be forgotten.

### VENUS

Venus, so beautiful to the unaided eye, is also a telescopic disappointment, for aside from its phases, which are always a source of interest to observe, there are no surface features within the range of our optical power.

The planet is best viewed in the twilight or just before the dawn, when the faint light of day serves to deprive the radiant orb of a portion of its brilliancy. Seen under these conditions the crescent Venus is one of the most beautiful objects in the heavens. Of course if the telescope is equatorially mounted, both Venus and Mercury can be seen in broad daylight.

### MARS

Because of the question of the habitability of Mars, it must ever be the most interesting of the planets to mankind, and the amateur astronomer has a never

failing source of pleasure in the observation of many of the surface markings on the planet, concerning which there has been so much discussion. This is especially true when the planet is nearest the earth.

The crescent phase never appears in planets which revolve outside the earth's orbit, but at times Mars appears gibbous like the moon, when it is three or four days from full.

At favourable oppositions, which occur once in fifteen or seventeen years, the more conspicuous dark markings, the "Hour Glass" or Kaiser Sea, and the polar snow caps, can be seen with our glass. The so-called canals, concerning which there has been so much controversy, can only be seen with the largest telescopes.

A power of 200 is recommended. The presentation in Sept., 1909, will be most favorable.

### JUPITER

Because of its colossal size, 86,000 miles in diameter, and its brilliancy, Jupiter is probably the most satisfactory of all the planets to view in a small telescope; for in addition to the markings on the surface of the planet which can be easily seen, the rapid changes in the position of its four principal satellites can be observed to advantage, and ever prove a source of pleasure and wonderment.

A power of 130 or thereabouts should be used. There is

no difficulty in seeing the two principal belts, and the elliptical shape of the planet will be at once noted. It is even possible, when the atmospheric conditions are favorable, to see the different colors of the belts that cross the planet parallel to its equator.

"A point on Jupiter's equator moves about 27,000 miles or considerably more than the entire circumference of the earth in a single hour. The effect of this motion is clearly perceptible to the observer with a telescope on account of the diversified markings and colors of the moving disk, and to watch it is one of the greatest pleasures that the telescope affords." The time of rotation is four or five minutes less than 10 hours. Jupiter would contain 1389 earths, and is larger than all the planets of our system put together.

The observation of the satellites of Jupiter will probably interest the amateur to a greater degree even than the view of the belts.

The four satellites, visible in our telescope, are named Io, Europa, Ganymede, and Callisto, beginning with the innermost, but they are generally referred to as I, II, III, and IV respectively.

So rapid are the changes in the positions of the satellites that the changes can be detected in a few hours of observation, and the amateur has a chance to verify the predictions as regards their respective positions in the ephemeris. Sometimes the four moons will appear on one side of the planet, and again two will appear on each side,

and this ever-changing scene, that is quite unique and different from anything else that human eyes behold, has a fascination about it that is peculiarly its own.

The sight of the eclipses, occultations, and transits of the satellites, and the transits of their shadows, is of unbounded interest. The view of transits of the moons is difficult for all save good instruments, but the shadows in transit are surprisingly distinct when the air is steady. The eclipses are accompanied by the phenomena of sudden disappearance and reappearance, and are of all the phenomena of the satellites most interesting to observe.

THE SATELLITES OF JUPITER

| | IO<br>I | EUROPA<br>II | GANYMEDE<br>III | CALLISTO<br>IV |
|---|---|---|---|---|
| Time of revolution | 1d., 18h. 28m. | 3d., 13h., 14m. | 7d., 3h., 43m. | 16d., 16h., 32m. |
| Diameter | 2500 | 2100 | 3550 | 2960 |
| Mean distance from planet | 262,000 | 419,000 | 664,000 | 1,170,000 |
| Characteristics | Rapid Motion | Largest and brightest | | Greatest orbit |
| Colors | Straw color | White | Rosy orange | Steel gray |
| Stellar magnitude | 5.28 | 5.31 | 4.88 | 5.98 |

The diameter of our moon is 2160 miles.

To assist the student in viewing the phenomena of the satellites of Jupiter a condensed portion of the nautical almanac relating thereto for a brief time follows.

It has been prepared solely with a view to save the student the trouble of looking up the data for himself, and to excite his interest in this fascinating phase of observational work.

The hours given are all convenient for observation, and the verification of the predictions, regardless of the wonderful and beautiful sight of the rapidly moving satellites, is one of the greatest pleasures of the amateur astronomer.

PHENOMENA OF THE SATELLITES OF JUPITER VISIBLE AT WASHINGTON AT THE TIME INDICATED DURING THE MONTHS OF JULY AND AUGUST, 1909, AND THE YEAR 1910

| DATE | TIME | SATELLITE | PHENOMENA |
|---|---|---|---|
| 1909 | h. m. s. | | |
| July 7 | 7 57 | I | Tr. In. |
| " 7 | 9 | I | Sh. In. |
| " 7 | 9 28 | II | Sh. Eg. |
| " 8 | 8 28 26 | I | Ec. Re. |
| " 8 | 8 43 | IV | Sh. In. |
| " 14 | 9 16 | II | Sh. In. |
| " 23 | 8 30 3 | III | Ec. Re. |
| " 23 | 8 44 | I | Tr. Eg. |
| " 30 | 8 25 | I | Tr. In. |
| Aug. 7 | 7 41 | I | Oc. Dis. |
| " 8 | 7 52 | I | Sh. Eg. |
| " 8 | 7 57 | II | Tr. Eg. |
| " 15 | 7 29 | I | Sh. In. |

During the remainder of the year Jupiter is not in a favorable position for convenient observation.

| DATE | TIME | SATELLITE | PHENOMENA |
|---|---|---|---|
| 1910 | h. m. s. | | |
| Jan. 31 | 11 4 | I | Oc. Re. |

| DATE | TIME | SATELLITE | PHENOMENA |
|---|---|---|---|
| 1910 | h. m. s. | | |
| Feb. 22 | 10 35 | I | Sh. In. |
| " 23 | 10 2 | III | Oc. Re. |
| " 23 | 10 48 | II | Tr. Eg. |
| " 23 | 10 51 | I | Oc. Re. |
| Mar. 2 | 9 9 | II | Sh. In. |
| " 2 | 9 46 18 | I | Ec. Dis. |
| " 2 | 10 28 | II | Tr. In. |
| " 2 | 11 2 56 | III | Ec. Re. |
| " 2 | 11 23 | III | Oc. Dis. |
| " 3 | 9 13 | I | Sh. Eg. |
| " 3 | 9 49 | I | Tr. Eg. |
| " 10 | 8 52 | I | Sh. In. |
| " 10 | 9 21 | I | Tr. In. |
| " 11 | 8 47 | I | Oc. Re. |
| " 11 | 9 59 | II | Oc. Re. |
| " 18 | 8 1 21 | I | Ec. Dis. |
| " 18 | 9 1 34 | II | Ec. Dis. |
| " 18 | 10 30 | I | Oc. Re. |
| " 19 | 7 45 | I | Tr. Eg. |
| " 20 | 7 39 | III | Tr. In. |
| " 20 | 9 1 | III | Sh. Eg. |
| " 20 | 9 45 | III | Tr. Eg. |
| " 25 | 9 54 54 | I | Ec. Dis. |
| " 26 | 7 8 | I | Sh. In. |
| " 26 | 7 15 | I | Tr. In. |
| " 26 | 9 23 | I | Sh. Eg. |
| " 26 | 9 29 | I | Tr. Eg. |
| " 27 | 8 49 | II | Sh. Eg. |
| " 27 | 8 56 | II | Tr. Eg. |
| " 27 | 10 25 | III | Sh. In. |
| " 27 | 10 55 | III | Tr. In. |
| Apr. 2 | 8 59 | I | Tr. In. |
| " 2 | 9 3 | I | Sh. In. |
| " 3 | 8 26 56 | I | Ec. Re. |
| " 3 | 8 31 | II | Tr. In. |

| DATE | TIME | SATELLITE | PHENOMENA |
|---|---|---|---|
| 1910 | h. m. s. | | |
| Apr. 3 | 8 40 | II | Sh. In. |
| " 10 | 7 54 | I | Oc. Dis. |
| " 10 | 10 20 44 | I | Ec. Re. |
| " 12 | 8 49 12 | II | Ec. Re. |
| " 14 | 7 3 | III | Oc. Dis. |
| " 14 | 10 45 8 | III | Ec. Re. |
| " 18 | 7 20 | I | Sh. In. |
| " 18 | 9 8 | I | Tr. Eg. |
| " 18 | 9 35 | I | Sh. Eg. |
| " 19 | 7 50 | II | Oc. Dis. |
| " 21 | 10 21 | III | Oc. Dis. |
| " 25 | 8 40 | I | Tr. In. |
| " 25 | 9 15 | I | Sh. In. |
| " 26 | 8 37 20 | I | Ec. Re. |
| " 26 | 10 8 | II | Oc. Dis. |
| " 28 | 8 22 | II | Sh. Eg. |
| May 2 | 8 47 | III | Sh. Eg. |
| " 2 | 10 26 | I | Tr. In. |
| " 3 | 7 34 | I | Oc. Dis. |
| " 3 | 10 31 35 | I | Ec. Re. |
| " 4 | 7 53 | I | Sh. Eg. |
| 5 | 8 14 | II | Sh. In. |
| " 5 | 9 22 | II | Tr. Eg. |
| " 5 | 10 56 | II | Sh. Eg. |
| " 9 | 9 17 | III | Tr. Eg. |
| " 9 | 10 19 | III | Sh. In. |
| " 10 | 9 21 | I | Oc. Dis. |
| " 11 | 7 33 | I | Sh. In. |
| " 11 | 8 55 | I | Tr. Eg. |
| " 11 | 9 48 | I | Sh. Eg. |
| " 12 | 9 1 | II | Tr. In. |
| " 12 | 10 49 | II | Sh. In. |
| " 14 | 8 33 11 | II | Ec. Re. |
| " 16 | 10 20 | III | Tr. In. |
| " 17 | 11 9 | I | Oc. Dis. |
| " 18 | 8 28 | I | Tr. In. |

| DATE | TIME | SATELLITE | PHENOMENA |
|---|---|---|---|
| 1910 | h. m. s. | | |
| May 18 | 9 28 | I | Sh. In. |
| " 18 | 10 43 | I | Tr. Eg. |
| " 19 | 8 49 4 | I | Ec. Re. |
| " 25 | 10 18 | I | Tr. In. |
| " 26 | 10 43 40 | I | Ec. Re. |
| " 27 | 8 6 | I | Sh. Eg. |
| " 27 | 8 22 1 | III | Ec. Dis. |
| " 27 | 10 32 15 | III | Ec. Re. |
| " 28 | 8 51 | II | Oc. Dis. |
| " 30 | 7 59 | II | Sh. Eg. |
| June 2 | 9 16 | I | Oc. Dis. |
| " 3 | 7 47 | I | Sh. In. |
| " 3 | 8 51 | I | Tr. Eg. |
| " 3 | 10 | III | Oc. Re. |
| " 3 | 10 1 | I | Sh. Eg. |
| " 6 | 7 53 | II | Sh. In. |
| " 6 | 8 12 | II | Tr. Eg. |
| " 6 | 10 34 | II | Sh. Eg. |
| " 9 | 11 8 | I | Oc. Dis. |
| " 10 | 8 28 | I | Tr. In. |
| " 10 | 9 42 | I | Sh. In. |
| " 10 | 10 43 | I | Tr. Eg. |
| " 10 | 11 10 | III | Oc. Dis. |
| " 11 | 9 1 51 | I | Ec. Re. |
| " 13 | 7 59 | II | Tr. In. |
| " 13 | 10 29 | II | Sh. In. |
| " 13 | 10 42 | II | Tr. Eg. |
| " 14 | 8 36 | III | Sh. Eg. |
| " 15 | 8 16 46 | II | Ec. Re. |
| " 17 | 10 21 | I | Tr. In. |
| " 18 | 10 56 42 | I | Ec. Re. |
| " 19 | 8 20 | I | Sh. Eg. |
| " 20 | 10 31 | II | Tr. In. |
| " 21 | 10 16 | III | Sh. In. |
| " 22 | 10 52 42 | II | Ec. Re |
| " 25 | 9 23 | I | Oc. Dis. |

| DATE | TIME | SATELLITE | PHENOMENA |
|---|---|---|---|
| 1910 | h. m. s. | | |
| June 26 | 8 | I | Sh. In. |
| " 26 | 8 59 | I | Tr. Eg. |
| " 26 | 10 15 | I | Sh. Eg. |
| " 28 | 8 56 | III | Tr. In. |
| " 29 | 8 16 | II | Oc. Dis. |
| July 3 | 8 39 | I | Tr. In. |
| " 3 | 9 55 | I | Sh. In. |
| " 3 | 10 54 | I | Tr. Eg. |
| " 4 | 9 15 14 | I | Ec. Re. |
| " 6 | 10 53 | II | Oc. Dis. |
| " 8 | 10 15 | II | Sh. Eg. |
| " 9 | 8 19 8 | III | Ec. Dis. |
| " 9 | 10 21 40 | III | Ec. Re. |
| " 10 | 10 35 | I | Tr. In. |
| " 12 | 8 33 | I | Sh. Eg. |
| " 15 | 10 11 | II | Sh. In. |
| " 16 | 9 45 | III | Oc. Re. |
| " 17 | 7 57 7 | II | Ec. Re. |
| " 18 | 9 40 | I | Oc. Dis. |
| " 19 | 8 14 | I | Sh. In. |
| " 19 | 9 17 | I | Tr. Eg. |
| " 26 | 8 59 | I | Tr. In. |
| " 27 | 8 26 | III | Sh. Eg. |
| " 27 | 9 28 57 | I | Ec. Re. |
| " 31 | 8 15 | II | Oc. Dis. |
| Aug. 3 | 8 6 | I | Oc. Dis. |
| " 3 | 8 14 | III | Tr. Eg. |
| " 4 | 7 42 | I | Tr. Eg. |
| " 4 | 8 46 | I | Sh. Eg. |
| " 9 | 7 56 | II | Tr. Eg. |
| " 11 | 7 26 | I | Tr. In. |
| " 11 | 8 27 | I | Sh. In. |
| " 12 | 7 47 34 | I | Ec. Re. |
| " 16 | 7 58 | II | Tr. In. |
| " 18 | 7 34 13 | II | Ec. Re. |
| Sept. 3 | 7 7 | II | Sh. Eg. |

During the remainder of the year Jupiter is not in a favorable position for convenient observation.

*Abbreviations*

| | |
|---|---|
| In. Ingress | Ec. Eclipse |
| Eg. Egress | Oc. Occultation |
| Dis. Disappearance | Tr. Transit of Satellite |
| Re. Reappearance | Sh. Transit of Shadow. |

The list is taken from the nautical almanac, is but a partial one, and includes only the phenomena visible at convenient hours for observing.

*Explanation of the Phenomena of Jupiter's Satellites*

The student may have some difficulty in understanding fully the phenomena of the satellites of Jupiter. A study of the diagram on the opposite page will, it is hoped, make the matter clear.

Let us suppose that Fig. 1 represents the view of Jupiter and his moons in the telescope using the celestial eyepiece;

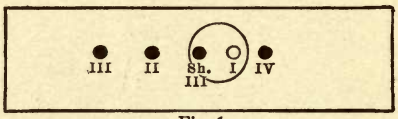



**Fig. 1**

To fully understand the real state of affairs let us consult Fig. 2. The observer is supposed to be at the point on the earth's orbit marked "A." As the plane of the orbits of Jupiter's moons is presented edgewise towards the earth, each moon appears to have the motion of a pendulum moving forward and back nearly in a straight line. At this precise time of our observation, I is between us and the planet, and in transit. As it is a

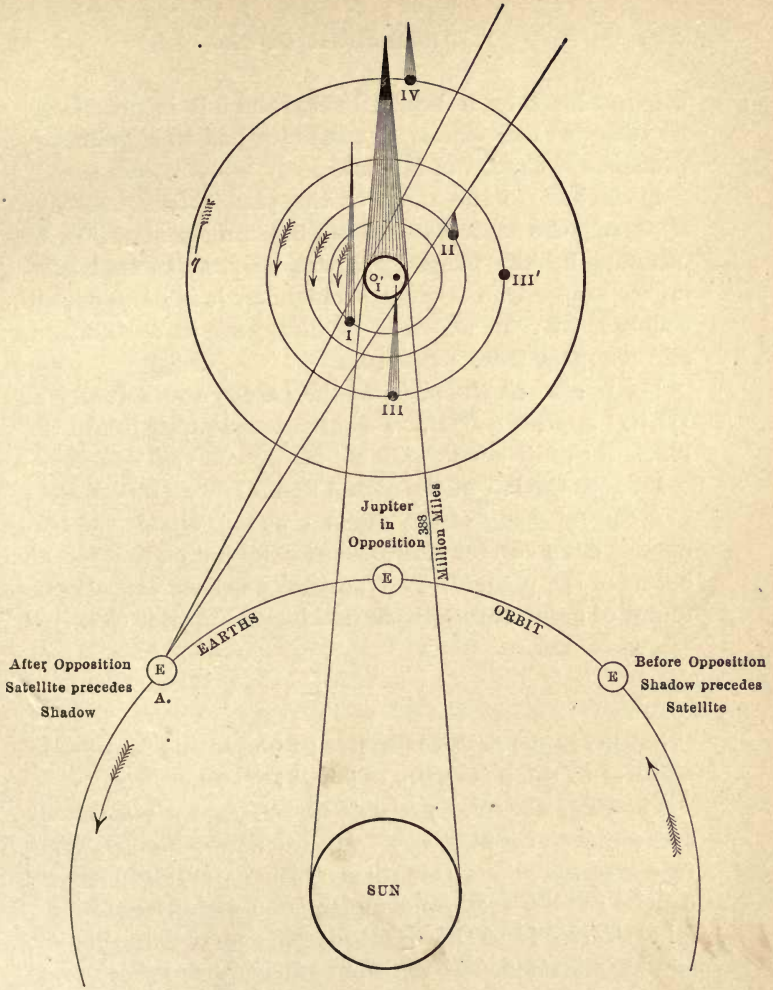

IV
II
III'
I
III
Jupiter
in
Opposition
Million Miles
383
E
EARTHS
ORBIT
After Opposition
Satellite precedes
Shadow
E
A.
Before Opposition
Shadow precedes
Satellite
E
SUN

Fig. 2.

bright object on a bright background it is practically invisible in our glass. Its shadow has not quite approached the point of ingress.

II is just to the right of the planet (the telescope reversing the true state of affairs) and is about to be occulted by the planet. It will be seen at once that on its reappearance from occultation it is immediately eclipsed, so that we have it disappear in occultation, and reappear from eclipse.

III is also at the right of the planet and actually at III but appears at III′. Its shadow is in transit and the black dot of its shadow should be seen on the planet.

IV is to the left of the planet and about to be eclipsed.

A careful study of the diagram should enable the student to get a correct idea of what is taking place when he observes the planet. The nautical almanac will also be found of great assistance in making the matter clear.

### SATURN

Saturn ranks next to Jupiter in presenting interesting features to the possessors of small telescopes.

The rings are clearly visible and present a marvellous and wonderful appearance. Its two largest moons, Titan (in appearance like an eighth magnitude star) and Japetus, can be readily seen, and under good seeing conditions, Rhea, Tethys, and Dione, moons still nearer to the planet, can be glimpsed, but the comparatively sluggish move-

ments of these attendants of Saturn render them uninteresting as compared with those of Jupiter. To see Tethys and Dione the planet should be screened from view. It is possible under favorable conditions to see the belts on the surface of the planet with our glass. The observer will at once perceive the elliptical appearance the planet, as in the case of Jupiter.

From a combination of circumstances, Saturn alternately exhibits each side to the earth, and the rings appear to increase and decrease in breadth. This phenomenon is gone through in a little less than fifteen years for each side of the rings. In 1907, because of the edge presentation of the rings, they were invisible in a small telescope. In a large telescope the rings at such a time resemble "a pair of illuminated needles stuck into the ball of the planet on opposite sides."

At present, 1908–9, the rings are plainly visible in a three-inch glass, and in 1915 they will be opened again to their widest extent.

The rings measure thirty thousand miles across, and are probably not over one hundred miles in thickness. They consist of an infinite number of small bodies revolving about the planet in a common plane. They were discovered by Galileo in 1610.

The two remaining planets, Uranus and Neptune, are too distant to offer any features of interest to the amateur observer. Uranus can be seen very well with a

three-inch glass. It is about as bright as a sixth magnitude star and consequently can be seen with the naked eye. It will be recognized in a telescope at once because of the absence of the diffraction ring which always encircles the star image in a good telescope. The disk of Uranus appears pale and diffused, that of a star is sharp and brilliant. The almanac is indispensable in locating it. Light from Uranus takes 2 hours and 28 minutes to reach the earth.

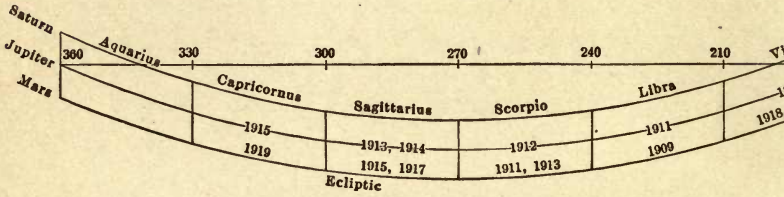
In a three-inch glass with a power of 250, Neptune looks something like an eighth magnitude star.

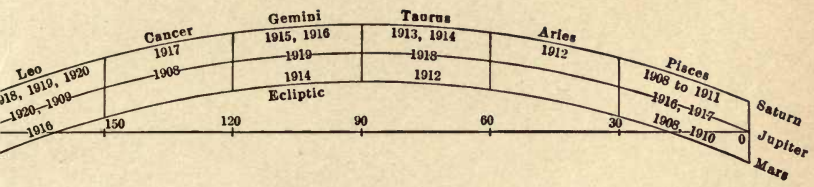
It would take a cannon shot 500 years to traverse the orbit of Neptune from side to side, speeding continually at its customary velocity. The nearest star is thousands of times farther distant from the earth than is Neptune.

## THE ECLIPTIC, SHOWING THE POSITIONS OF SATURN, JUPITER, AND MARS, JANUARY FIRST, FOR TWELVE YEARS.

The dates on the upper, middle, and lower lines indicate the positions of Saturn, Jupiter, and Mars respectively.

The movement is from right to left.






## PLANETARY DATA

| PLANET | DISTANCE FROM SUN IN MILLIONS OF MILES | DIAMETER IN THOUSANDS OF MILES | PERIOD OF REVOLUTION ABOUT SUN | PASSES THROUGH ONE CONSTELATION IN |
|---|---|---|---|---|
| Saturn | 886 | 73 | 29.46 Yrs. | 2½ Yrs. |
| Jupiter | 483 | 88 | 11.86 " | 1 Yr. |
| Mars | 142 | 4 | 686 Days | 57 Days |

# THE SUN

## THE SUN

THE possessor of a three-inch telescope may derive much pleasure and profit by observing the sun, but great care must be used or the sight will be permanently impaired. Many telescopes are equipped with shade glasses of neutral tints, which, when screwed to the eyepiece, admit of direct solar vision. If this method is used, the aperture of the objective should be decreased by means of a diaphram placed over the objective, otherwise the heat is liable to crack the solar eyepiece, thus endangering the eyesight.

A smoked glass may also be used in place of a solar eyepiece, and answers very well if it is well covered, but it is a dangerous method to employ, and rather than take the risk, the method of viewing the sun by projecting its image on a screen should be adopted. This, in addition to being perfectly safe, permits a number of persons to view the solar phenomena at the same time. It is best to fasten the screen to the telescope by a light framework, over which a black cloth should be stretched to keep out the light, and render the image more distinct. As a further screen, the object glass should be allowed to project through a piece of cardboard.

It is unnecessary and dangerous to locate the sun by the use of the finder, as by experimenting a little the sunlight can be made to appear on a paper held close to the eyepiece.

If one can afford it the most satisfactory views of the sun are to be had through a solar prism, or a helioscope, which enables the observer to control the amount of light passing through the eyepiece, and permits of a direct view of the solar phenomena without running any danger of ruining the eyesight.

The phenomena of especial interest to the observer with a small telescope are the sun spots. There is seldom a time when there are not one or more spots on the sun, and the changes to be noted in them, and their apparent daily motion across the sun's disk, are well calculated to interest the student; especially when he considers the magnitude of many of the spots, as he can well do by comparing them with the diameter of the sun, which is 866,000 miles.

The mean rotation period of the sun is twenty-five days. On the average, the spots travel across the sun's disk in a little over fourteen days.

The spots often change perceptibly from day to day. Some are obliterated in a few days, while others appear to remain intact, and are seen for several successive periods of revolution. It is good practice to sketch the spots as they are observed. In this way the changes in their appearance can be easily noted.

Excellent views of the spots may be had through the solar eyepieces, by inserting between the lenses of the regular eyepiece a piece of cardboard, which has a hole pierced through its centre with a red-hot needle. This method brings to light considerable detail.

It has been determined that the magnitude and number of the spots wax and wane in a period of about eleven years. Near a minimum time the visible surface of the sun may be free from spots for weeks, while at maximum they can be seen almost every day, some being large enough to be seen through a smoked glass with the naked eye. A maximum was reached about 1904–05.

As to the nature of the spots, no theory as yet propounded fully explains the phenomena. It has been observed that during maximum periods of sun spots, magnetic storms on the earth and displays of the aurora borealis frequently occur, so that in all probability there is some connection between them.

Eclipses are of course of the greatest interest to observe of all solar phenomena, especially the total eclipses, which unfortunately seldom occur. In regard to them, the almanac will supply the necessary data as to time and visibility.

The so-called solar prominences are the most spectacular of all the solar phenomena. They are geyser-like fountains of hydrogen and helium gas that spurt out from the sun's surface, sometimes rising to a height of 350,000 miles. They can only be seen when on the sun's

limb, and then only through a spectroscope. It is possible to attach a spectroscope to a glass of only three-inch aperture and surely to one who can afford such a luxury the spectroscope thus employed will yield a mine of enjoyment.

The matter of solar observation is merely hinted at here. There is a wealth of material on the subject at the command of the student. It is only necessary to call attention to the danger of observing the sun without interposing a semi-opaque medium and to mention briefly the phenomena observable in a three-inch telescope.

Astronomers are paying more attention to the sun at present than ever before. The fact that it is the nearest star to the earth renders it most worthy of our observation and every new fact relative to its nature and the character of its phenomena is of prime importance to the race.

Because of the strides now being made in solar photography, there is every reason to hope that in the very near future the nature of the sun spots, at least, will be revealed.

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